Towards Less Refrigeration-dependent Home Practices

Min Qian

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Centre for Development and the Environment

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1. Introduction

1.1 Background and objective

There are emerging concerns about sustainable energy production and consumption worldwide. The alarming prospect that "global energy demand, consumption and CO_2 emissions (…) under the 'business as usual' scenario (…) are likely to double by the year 2050" (See also IEA, 2006) has left us four possible policy choices: "improving energy efficiency, increasing the share of renewable energy sources, changing life-styles, and improving global governance in order to prevent conflict over resources" (Matutinović 2008:199).

Over the past 20 years, it is clear that more emphasis has been laid on the development of technology than on the reduction of consumption. It might be because, as Wilhite and Norgard put it, "the policy and research at the centre of the discourse on energy sustainability suffer from a self-deception, which revolves around the equation of 'efficiency' with 'reduction'" (2004:992). The authors of the famous book *Factor Four: Doubling Wealth, Halving Resource Use* claim that people can save three-quarters of the energy and materials we consume today with technological innovation and ultimately solve the recent environmental problems (See also Weizsäcker et al. 1997, Throne-Holst & Strandbakken 2005:40). This "techno-optimist" trend can also be detected in the foreword of the book Sustainable Technology Development: "(…) one of the main responsibilities of the present generation to future generations is to work today to find technological breakthroughs with the potential to deliver eco-efficiency improvements of the needed scale within the relevant time constraints" (See also Jansen and van Grootveld 2000, Throne-Holst & Strandbakken 2005:40). With the support of this technological efficiency

deception, more consideration has been given to the technical efficiency of the appliances while little consideration has been given to the actual patterns of energy use.

There have been significant gains in energy efficiency with research and policy efforts moving towards energy sustainability over the past few decades, however, we can't deny the fact that the total energy consumption in the OECD countries as well as some developing countries has grown rapidly with ever increasing economic activities. In this sense, according to Wilhite and Norgard, "that technological efficiency alone will offset continued growth in energy services to the extent that deep reductions in energy use are possible" seems to be problematic in reality although they contend that some of the growth in energy service can be kept under control by using renewable energy (2004: 992). They further point out the fact that "(…) global warming is not the only energy related environmental problem, and that essentially all forms of energy supply have associated environmental impacts" (See also Johansson et al. 2001, Meadows et al. 2004, Wilhite & Norgard 2004:992). Therefore, in the long run, we should not overestimate the importance of technological development though it is "an important factor when we envision a sustainable society" (Throne-Holst & Strandbakken 2005:40).

There are calls on researchers and policy makers to move focus from energy to energy services in recent literature. Elizatbeth Shove argues in *Comfort, cleanliness + Convenience* that "domestic consumption of energy depends on the introduction of new consumer durables, on how such devices and resources are used and on the services they provide" (2003:14). Wilhite and Norgard also claim that "(…) global energy use will continue to increase unless European and other rich OECD countries aim at significantly reducing their energy consumption, which would imply curbing their energy services (…)" (2004:992). Harald Throne-Holst and Pål Strandbakken also emphasize an extensive consideration of the implementation and actual use of modern

appliances, or put in another way, people's consumption patterns or lifestyle (2005). Matutinović further states that "(…) only change in western life-style might achieve a deep reduction in energy consumption and its stabilization on a 'temporary' sustainable level" (2008:200).

This paper looks at cooling –refrigeration – one of the major functions included in the energy services. For a long time, energy efficiency in the cold storage system is primarily achieved through the adoption and appropriate application of more energy-efficient technologies. The significance of a substantial reduction of the household energy demand was first declared in a Directive from the European Commission in 2003 on household refrigerators and freezers (Throne-Holst & Strandbakken 2005:39). In a working paper produced as part of the work of the Food Climate Research Network (FCRN) in the UK recently, Garnett argues that energy-efficiency measures and novel technologies are essential to energy-savings in household food refrigeration system and in the cold chain, but there are still practical limitations in explaining people's dependence on refrigeration in their daily lives. She examines people's refrigeration dependence by exploring "(…) the social, economic, cultural and commercial developments that may have fostered this trend". Her attention also goes to the energy demand in the frozen food business chain, both the frozen food itself and the technological infrastructure, and she calls on an energy reduction both by improving the energy efficiency of the equipment itself and by reducing people's dependence on the cold chain (2007:4-12).

This paper will focus on household food refrigeration energy services and the research will mainly cover the historical period beginning 1900 and ending in 2008. It seeks to analyze the way refrigeration is perceived by Norwegians in a historical perspective, to understand the everyday use of refrigerators and freezers in Norway in a social-material context, and, ultimately, to look at

whether it is possible to reduce the household energy consumption by reducing people's dependence on energy-intensive refrigeration appliances.

1.2 Energy use in perspective

It seems to have long been a mission impossible for scholars and practitioners of different disciplines to come to an agreement for the definition of energy consumption. Theoretical work in energy use has long laid more emphasis on technological development rather than take it as a social phenomenon. Not until the 1970s energy crisis did social scientists worldwide begin to take an interest in consumption as a social problem (Wilhite et al. 2000). As Daniel Miller claims, "(…) there has been a considerable and relatively sudden expansion of interest in the topic of consumption throughout the social sciences" (Miller 1995:1). This interest taken by sociologists, anthropologists and human ecologists has led to a long-standing discussion on the technological and environmental foundations of human society within the sociological research agenda of consumption. Thus, the sociology of consumption has experienced a series of shifts and adjustments between the production-dominated paradigm and the consumption-oriented one (Campbell 1995:96). Here, I intend to approach my research primarily by drawing from literature three theoretical interpretations in understanding energy use.

1.2.1 The device-centred perspective

The device-centred approach since the early 1980s has focused on the technology of energy production and consumption, in other words, "machines, devices (i.e. furnaces, motors, lights, water heaters, air-conditioning compressors, etc) and buildings" are taken as energy *users* (Wilhite et al. 2000:110). The end-use technologies are generally represented in engineering projects for an efficiency measurement. As Wilhite put it,

> Elaborate mathematical models designed to mimic the "performance" of buildings and equipment – both individual devices and structures, as well as large populations or "stocks" of buildings and appliances – were constructed and used to estimate the effects of energy conservation initiatives, to assess the impacts of device-by-device efficiency improvements, to predict future changes in aggregate energy demand, and to explore the effects of policy on alternative societal level energy usage patterns. (2000:110)

In these models, technological improvement and energy efficiency are centered while "the existing market barriers to the diffusion of these technologies", the human demand for energy services, and various behavioral practices in the actual adoption of the new technologies were believed to be unimportant parts of the energy-using system subject to analysis (Weyant & Yanigisawa 1998: 216). However, it turned out to be problematic for these modeling systems "to match physical models with measurements of real world energy flows" because human beings, as active energy *users*, were actually manipulating devices and interacting with energy flows at any turn of the energy system (Wilhite et al. 2000:111).

1.2.2 The techno-economic perspective

The techno-economic approach treats energy consumption with an emphasis on both technological progress and human ingenuity. Ehrhardt-Martinez described it as:

> This approach tends to conceptualize changes in energy-efficiency using a techno-economic model focused on two core variables: the development of energy-efficient equipment and technologies, and the economic framework in which decisions to adopt more efficient technologies are made. (2008:6)

The economics' treatment of consumer behaviour mirroring in the approach carved out "a 'behavioral' niche in energy research for the social sciences" (Wilhite et al. 2000:111), and some anthropologists and sociologists started to turn their attention to individual decision-making from merely technical understanding of energy use.

However, many explanations of energy consumption from a techno-economic viewpoint were in essence a neoclassical economical understanding. These analyses were limited to individual consideration of the costs and benefits associated with adopting energy-efficient devices, and thus, inevitably involving consumers' independent preferences. This approach, to some extent, only suggests " a logical expert defines a more efficient solution through a process of research and demonstration and the consumer adopts it and applies it when it is in his or her economic interest to do so" (Ehrhardt-Martinez 2008:7). In this sense, the social and material contributions to consumer demand were neglected, and energy consumption was narrowed down to consumer preferences and sovereignty (Wilhite 2010: Lecture 1). This techno-economic viewpoint, according to Fine, bears the underlying assumption that consumption is nothing but individuals' cost-minimizing behaviour depending on income available "when prices are fixed for the goods involved" (1995:128-129).

In all, the concept of individual behaviour merely provides a narrow understanding of energy consumption although "human action is the central and controlling element of energy systems" (Wilhite et al. 2000:112). According to Wilhite et al., "if one accepts that significant changes in the ways we use energy will be predicated on a significant social transformation, then focusing on behaviour of individual end-users as the only key to change is both overly simplistic and counter-productive" (2000:114).

1.2.3 The practice perspective

The practice perspective of consumption can be considered as the complement of the device-centered approach, and meanwhile, it is one of the alternative conceptualizations to the economic theory of consumer behaviour. Reckwiz defined a practice as "a routinized type of behaviour which consists of several interrelated knowledge; individuals, with their values and knowledge; routines,

bound together with ‘tacit knowledge’; things, which also have knowledge in the form of ‘scripts’ for behaviour” (Cited by Wilhite 2010:Lecture 6).

When applying this practice theory to energy use, those social scientists outlined a social material conceptualization of energy consumption, something much broader than a science of energy behaviour. From this perspective, individuals are no longer passive knowledge receivers to perform practices or “free or sovereign agents revealing their preferences through market decisions”, but knowledgeable and skilled participants in practices (Wilhite 2010:2-3); routinized ways of life are situated and inscribed in the knowledge about practice which is “distributed between socio-cultural contexts around practices, the individuals who perform them, the routines which develop in them, and the technologies deployed” (Wilhite 2010:2); tools, devices and material objects possess a *script* (Verbeek 2006:362) which can co-shape or reconfigurate people’s perceptions, actions and “habits associated with their use and appropriation” (Shove 2003:11-12).

This multi-dimensional framework of energy consumption has moved the focus of social science research from technologies and individuals to routines, materials and their social practices. It has been useful in “understanding escalating demand for energy-intensive services, practices and ways of life” (Wilhite 2000:117). In this sense, the practice perspective moves beyond a narrowly behavioral perspective and sets up a new agenda for the study of energy consumption.

The energy use perspectives can be summarized as follows: (1) The device-centered view, which is the most restrictive model in understanding energy use, has been particularly successful in developing models of the energy saving potential of specific technologies, but less successful at explaining the variation in cultural energy use and savings “due to its inability to address the human dimensions associated with technology dissemination and adoption” (Ehrhardt-Martinez 2008:7). (2) The techno-economic view recognizes the

expansive potential of the human actions in analyzing energy system, but seeks to restrict that potential through an economic interpretation and ignores dictates of the cultural and social contexts in which energy intensive services are demanded. (3) The practice perspective, which incorporates energy demand as the result of interactions between technologies, routines, and human practices in a social and material context, is essential to understand energy consumption by breaking through the long-dominating "individualistic, techno-centred and market-oriented" research and policy agendas (Wilhite 2010:10).

In this study, the practice theory is applied to interpret how people, routines and contexts contribute to the change in the household energy consumption for food refrigeration. The research focus will be broadened from individuals and individual refrigerating devices to clusters of home practices associated with food refrigeration practices such as cooking, shopping, domestic heating and so on.

1.3 Household food refrigeration related energy use

The consumption area of the cold chain still remains greatly uncertain, as Garnett claimed "yet no comprehensive and authoritative estimates as to its overall consumption exist" (2007:13). Food manufacturing and processing enterprises, food retailing outlets, refrigeration transport and domestic refrigeration all contribute to the cold chain related energy use. This study focuses on the energy use of home refrigerators and freezers, "appliances that account for a significant share of household's domestic energy use, approximately 15 per cent as an Organization for Economic Cooperation Development average" (See IEA 2003:29-30 for a review, Strandbakken 2009:146).

The refrigeration appliances used in the households varies widely by type and age and there are also wide variations in the way that refrigerators and freezers are monitored and managed. Therefore, it's perhaps impossible to make a comprehensive and accurate measurement to their energy consumption (Garnett 2007:13). In order to achieve a rough assumption to the energy use of household refrigerators and freezers in this study, two main factors are taken into consideration: first, the potent greenhouse gases currently stored in the equipment and released every year; second, current and potential consumption of electricity in the household refrigeration sector.

The greenhouse gases stored in the cooling and freezing equipment for food are mainly HFCs. According to *The Norwegian Emission Inventor*, there is no production of HFCs in Norway, and hence all emissions of these chemicals originate from imported chemicals (2010:110). HFCs have been increasingly used in Norway as refrigerants in refrigerators and freezers as substitutes for CFCs and HCFCs since 1990 when these two types of chemicals were phased out according to the Montreal Protocol (Hansen 2007:3). Studies have indicated that "a household refrigerator imported to Norway will normally contain around 140 grams of HFCs. Part of this will slowly leak out from seams and ruptures during the lifetime of the refrigerator" (Hansen 2007:9). Every year about 1% of the initial charge of the chemicals in household refrigerators and freezers are released into the air and the average lifetime of domestic refrigerators and freezers is 15 years (Hansen 2007:11). That is to say, considering that at least two refrigeration appliances were in use in 92 per cent of the total 2 104 531 Norwegian households in 2008[1], a minimum 15 years' potential storage of HFCs in the household refrigeration appliances

[1] Statistics Norway (2010): "Table: 06078: Private households and persons per private household (C)." [online]. –URL: http://statbank.ssb.no/statistikkbanken/selectvarval/define.asp?SubjectCode=02&ProductId=02.01&MainTable=HusholdPrivat6&contents=Husholdniger&PLanguage=1&Tabstrip=SELECT&Qid=0&nvl=True&mt=0&pm=y&SessID=4980478&FF=2&gruppe1=Hele&gruppe2=Hele&VS1=Fylker&VS2=&aggresetnr=1. (retrieved April 8th, 2010).

amount to over 8 million kilograms[2]. Although "the leakage rate, or emission factor, varies considerably depending on type of equipment" (Hansen 2007:9), an expanding amount of HFCs from household refrigeration has definitely contributed to a significant part in the bank of HFCs. The HFCs stored in cooling equipment in Norway has already amounted to more than 4.8 million tonnes of CO_2-equivelants (Hansen 2007:11-12) and the bank still keeps growing. All these stored chemicals will eventually end up in the atmosphere until the bank is empty.

The energy consumption of domestic refrigeration appliances for food is powered by electricity. According to the report *Electricity Demand and CO_2 Emissions of Appliances*, an ordinary energy-efficient refrigeration unit consumes on average 1.2 KWh per day (2003:35). In this sense, the minimum electrical power for food refrigeration for Norwegian households amounted in total to about 1.7 TWh[3] in 2008, almost 5 per cent of the total household electrical power consumption and responsible for approximately 3.8 per cent of the total household CO_2 emissions[4].

1.4 Food preservation in perspective

1.4.1 The Norwegian food preservation tradition

"We have been extending the natural life of our food one way or another for a very long time" (Garnett 2007:31). In Norway, the traditional methods to preserve food include drying, smoking, salting, etc., some of which are still in

[2] 15 years' minimum storage of HFCs in Norway:
140 gram*2*2 104 531*92%*15=8 131 907 784 gram.

[3] Minimum electricity use of refrigerators and freezers in Norwegian households (KWh):
1.2*2*2 104 531*92%*365/2%=1 696 083 624 KWh.

[4] Statistics Norway (2010): "Table: 07207: Economic and Environmental Accounts – Air emissions." [online]. –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selectvarval/define.asp&Tabellid=07207. (retrieved May 19th, 2010).

use today and enable food to be stored or transported safely before consumption (Riddervold 1993).

Dried food has a long tradition in Norway. During Medieval Times, the Norwegian fishermen already learnt to preserve fresh fish by turning them into extremely hard "stockfish" in dry and cold wind (Wilson 1991:5). The dried fish was almost indestructible and had a long storage life of several years. "Besides oil, gas and income from the merchant fleet, stockfish is Norway's longest sustained export commodity and socioeconomically, the most profitable export over the centuries"[5].

Salting has a history of over 500 years in Norway. Cod started to be salted in the maritime nations of northern Europe when salt from southern Europe became economically feasible in the Scandinavian countries during the 17th century. "Traditionally, salt cod was dried by the wind and the sun, hanging on wooden scaffolding or lying on clean cliffs or rocks near the seaside"[6].

The history of dry-cured meat products can be dated back to as early as the Viking age. Traditionally, dry-cured meat products like lightly smoked dry-cured hams and unsmoked Norwegian dry-cured meat specialty called "Fenalår" (dry-cured lamb leg), are produced and preserved in the cold climatic condition with low water activities (Asefa et al. 2009:435-436). Nowadays, different types of industrially-produced dry-cured meat products are still available in almost all supermarkets and they are still one of the most popular dishes in Norway.

These traditional methods of food preservation are cheap and effective in the climatic conditions of Norway, the work can be done by the fisherman and

[5] Wikipedia–The Free Encyclopedia (2011): "Stockfish." [online]. –URL: http://en.wikipedia.org/wiki/Stockfish. (modified March 27th, 2011).

[6] Wikipedia–The Free Encyclopedia (2010): "Dried and Salted Cod." [online]. –URL: http://en.wikipedia.org/wiki/Salt_cod. (retrieved December 5th, 2010).

family, and the resulting product is easily preserved and transported due to its long storage life of several years.

1.4.2 A brief history of food refrigeration in Norway

1.4.2.1 Natural refrigeration

The history of food preservation by cooling in Norwegian households has long been accompanied by the use of ice and the development of natural refrigerating devices. Natural refrigeration was used by man in a more or less distant past to preserve food in the home when man realized that food-stuffs were better kept in cold air. Chinese started ice-cutting and ice-storage as early as about 600 B.C. and built ice houses from the 8th century. Many other ancient cultures shared similar practices in storing ice harvested in winter for use in summer (Garnett 2007:31). Natural refrigeration has long been a vibrant part of food preservation in Norway, but there is comparatively less recorded information on refrigeration activities in Norway than in other western countries.

Ice-box

A domestic ice-box was a wooden box with hollow walls that were lined with tin or zinc and packed with narrow insulating materials such as cork, sawdust, straw or seaweed. A large block of ice was kept in a tray or compartment near the top of the box or in the drawer above the door so that cold air could circulate down and around storage compartments in the lower section. The user normally obtained ice from an iceman regularly.[7]

Domestic ice-boxes were invented in 1803, and they were being made in the U.S.A. for almost 150 years before mechanical refrigerators began to be mass-

[7] Wikipedia–The Free Encyclopedia (2011): "Icebox." [online]. –URL: http://en.wikipedia.org/wiki/Icebox. (modified January 27th, 2011).

produced throughout the world (Thévenot 1979:172). In Norway, it was common during the summer to see men deliver ice to users in and around the cities and villiages until 1830, as it was recorded by Romsdalsmuseet: "Fram til 1930-årene var det vanlig om sommeren åse vognmennene kjøre is til kunder rundt i byen. Blokkene låda gjerne på striesekker for ikke ågli av vogna" (Berg 1979:23). Later, in the 1950s, ice-boxes were replaced by modern refrigerators and freezers and the old ice and *isrenner* were gone (Berg, 1979).

Larder

Larders were commonplace for storing food in the houses before refrigerators became widespread. Usually a larder was a cool place close to the kitchen and it should be properly equipped with shelves and cupboards appropriate for the food storage[8].

A larder was constructed as one part of the house for food preservation in Norway, especially in north Norway, in the first half of the 20th century (Hage 2007). It was mostly placed on the north or east side of the home where it received least amount of sun. Later the ventilated food cupboard took the place of the larder before electricity and pipe water covered most areas, as was stated in *Reconstruction Housing in North Norway: Gender and the Reception of the Modern Era*, "(…) the houses in the countryside should have a large kitchen, with a dining table and a larder, (…) But two years later, (…) kitchens were smaller and the larder had gone, replaced by a ventilated food cupboard in the kitchen" (Hage 2007:31).

[8] Wikipedia–The Free Encyclopedia (2010): "Larder." [online]. –URL: http://en.wikipedia.org/wiki/Larder. (modified November 7th, 2010).

Kjellar* VS *stabbur

Stabbur and *Kjellar* were both popular storage places for food in the family before the use of mechanical refrigeration.

Stabbur, big or small, was a separate building outside the main house. It mainly functioned as a storage place for food and food related commodities before the 1850s in Norway, as was described by Bjørn Austigard (2006:183), "Stabbur was primarily a storehouse for food and food related commodities (my own translation)".

Kjellar, cellar or basement in English, appeared in the late 1850s. Over the following 20 to 30 years, Norwegian farmers started to build two-storey houses with a basement due to the new Land Consolidation Act (*nye jordskiftelova*) in 1857 (Austigard 2006:197). At first, people stored only potatoes in the *Kjellar* , however, people began to keep their vegetables, fruit and berries in the *kjellar* instead of in the *Stabbur* since 1900, as described by Bjørn Austigard:

> Vegetables, apples, juice and jam may be stored frost-free, and thus increase the use of a good cellar. They picked wild berries and cooked them, i.e. cranberries and kept them in large jars (…). They kept well-cooked meat products in a container with a thick fat cap in the dark and cold cellars. (My own translation) (2006:197)

In this way, *Kjellar* got in its way of increasing popularity for daily food storage at the expense of the *Stabbur*.

1.4.2.2 Mechanical refrigeration

In the 1890s, natural refrigeration started to give way to mechanical refrigeration with the refinement of cooling technology although "technically it was not easy to make reliable, entirely automatic equipment" (Thévenot 1979:172). From the early 1900s onwards, mechanical refrigeration systems,

using carbon dioxide (CO_2) or ammonia as refrigerant, were increasingly adopted for ice-making, cold storage and breweries (Briley 2004:32).

Mechanical refrigeration was mainly taken up in the industry sectors until "Kelvinator launched the household (domestic) mechanical refrigerator in 1918" (Thévenot 1979:172). Then, domestic refrigerators became a mainstream household fixture rapidly in the United States. By 1937, 49% of American households had a mechanical refrigerator (Thévenot 1979:173) and by the late 1940s, over 60% of the households had one (Garnett 2007:33).

In Norway, refrigeration activities in the interwar period were common place in the food industry, especially the freezing of fish, as recorded in *A History of Refrigeration throughout the World*:

> (…) in 1918 there were 3 factories for freezing of fish. During the 1930's, Norwegian vessels conducted campaigns of freezing at sea, mainly of halibut and whale, and an export trade in frozen fish was organized; (…) Between 1937 and 1939, four herring freezing factories were equipped in the north, (...). Further, Norway had a large fleet of ships for the carriage of fruits, especially bananas. Refrigeration in abattoirs and dairies was satisfactory. Some industries, especially Norsk Hydro, had very large refrigerating plants. (Thévenot 1979:239)

It is striking to see that Norwegian refrigerated fish could be shipped worldwide, but it was not until after the Second World War that the household refrigerators and freezers began to be available in Norway (Strandbakken 2009:148). Domestic refrigerators and freezers were very rare at that time and only rich families could afford one. It was not until the late 1960s that the domestic refrigerators and freezers entered the mainstream market in Norway, yet more than 20% of the population still didn't have a refrigerator in 1967, and just very few households had a freezer. Refrigerators gained their popularity in Norway in early 1970s while freezers became a popular household fixture as late as 1980s (Table 1).

Table 1: Ownership of refrigeration appliances, Norway 1967-1988.

Year / Type	1967	1973	1981	1988
	Percentage of households owning a refrigeration appliance (%)			
refrigerator	74	92	99	99
freezer	34	66	88	88

Source: Extracted from Statistics Norway (2010): "Boliger og boforhold – Table 13.4 Percentage of Households with Different Types of Equipment." [online]. –URL: http://www.ssb.no/emner/historisk_statistikk/tabeller/13-13-4t.txt. (retrieved December 1st, 2010).

However, "the Norwegian market for refrigerators and freezers today is *saturated*", and 98% of the households in Norway have refrigerators and 92% have freezers (Strandbekken 2009:148). How people shop, prepare and consume food in their daily life is quite dependent on the existence of refrigerators and freezers. Many households own even more than one fridge or freezer. As described in *From Theory to Practice – Towards an Efficiency of Consumption*, regularly old refrigerators or freezers are still kept in use in the garage, basement or cabin once new substitutes are bought, thus the old ones are "most likely as a 'back-up' cold appliance for sodas, beers and pizzas, and situations where there is an extra need for capacity, like parties" (Throne-Holst & Strandbakken 2005:43).

1.5 Methodology: qualitative research

This study is based on a qualitative research method, starting with a literature review of relevant empirical experiences, followed up by open-ended interviews with informants and completed with an interpretative analysis of qualitative data from the field.

1.5.1 Qualitative research

Qualitative research, with rich, detailed and valid data, best contributes to an in-depth understanding of connections between various actors in this study because this research method, according to Geertz, is "not about seeking an experimental science in search of law but an interpretive one in search of meaning" (1973:5). A qualitative research provides the basis for a "thick description" (Fielding & Schreier 2001). The aim of this research is to describe and understand the energy use behaviour of local Norwegians in a social-material context and, ultimately, explore the ways that the energy intensity of household refrigeration can be reduced. It is important for me to be able to explain how different agents, especially refrigeration technologies, daily routines as well as social traditions influence people's perceptions, attitudes and beliefs on their routinized management of refrigerators and freezers. Here the research seeks to explore individual concepts of things and underlying meanings behind particular phenomena in a certain socio-cultural context. Therefore, analyzing people's food refrigeration behaviour in a qualitative method would afford me a basis with which to study the interconnections between energy users and various agents, and eventually, to understand why people are so dependent on food refrigeration and whether it is possible to cut down household energy use by reducing energy-intensive refrigeration dependence in people's daily life.

"Qualitative research is fundamentally interpretive" (Creswell 2003:182) and "anthropological writings are themselves interpretations" (Geetz 1973a:15). The quality of the findings in this research itself is directly dependent on the skills, experience and observative power of the researcher. This inevitable dependence might probably lead to two main sources of bias in this qualitative work: "the tendency to select field data to fit a preconception of the phenomenon and how it should be analyzed, and a tendency to select field data for analysis which are conspicuous because they are exotic at the expense of

less dramatic, but possibly more indicative, data" (Fielding & Schreier 2001). To avoid the possible bias, I tried to get as much information as possible from the literature review prior to the fieldwork and constantly reminded myself that the aim of this study was not to prove my own personal opinions or presuppositions on energy use in household food refrigeration systems, but to get a comprehensive understanding of people's dependence on energy-intensive cold appliances and to further examine the possibility to reduce this dependence.

1.5.2 Sampling

In almost all cases, it is simply not possible to collect data from a whole population due to limitation in time or resources for the research, therefore, "we need to sample: to select a small group which is representative of the wider population" (Overton & Diermen 2003:42). According to Creswell, "the purposeful selection of participants represents a key decision point in a qualitative study" (1998:118).

1.5.2.1 Sampling strategy

The sampling strategy involves ethnographers' judgment to select members from "people representative of the cultural-sharing group in terms of demographics, and the contexts that lead to different forms of behaviour" (Creswell 1998:100) and, in most cases, it aims to gather the most prominent views and perceptions from a certain number of reasonably-selected representatives of the population.

The sampling method adopted in this study is "snowball (or chain) sample" (Overton & Diermen 2003:43). "Snowball sampling is a method that has been used in the social sciences to study sensitive topics, rare traits, personal networks, and social relationships. The method involves the selection of samples utilizing 'insider' knowledge and referral chains among subjects who

possess common traits that are of research interest" (Kaplan et al. 1987:566). "This can be a useful technique for selecting respondents with particular characteristics where information on people with those characteristics is lacking" (Overton & Diermen 2003:43). In the study, I tried to cast my information network as widely as possible and gather as much data as I could for a detailed interpretation of energy patterns. I was assisted by those who I acquainted in the process of constructing of my information network because I am not a local Norwegian. By asking the local inhabitants such as my neighbours and friends, I could find the follow-up list of people who suited my research criteria and, meanwhile, showed their interest to be interviewed. In this way, my sample kept expanding. Snowball sampling can be the most practical means of sample selection for my study, however, this method "runs the risk of being very selective – some of your respondents may not know, or want to exclude" (Overton & Diermen 2003:43). Therefore, I kept in mind what Creswell claimed as "clear criteria" all through the design of the study and always tried to provide rationales for my decision (1998:118).

1.5.2.2 Sampling area

The natural setting for this study was Bærum municipality and Oslo, both of which are densely populated areas with comparatively high electricity consumption in Norway. According to Statistics Norway, Oslo is the largest city in Norway with a total population of 560 484 and Bærum, located on the west side of Oslo, is the most densely populated municipality in Akershus. The households' use of energy in these two areas in 2008, mainly covered by electricity, amounted to 5301.4 GWh, accounting for more than one tenth of the total households' energy use in Norway[9]. These two areas were chosen as the primary site of the ethnographical study also for the reason that the house I

[9] Statistics Norway (2011) "Energy use by municipality 2008-2009: Reduced Energy Use." [online]. –URL: http://www.ssb.no/english/subjects/01/03/10/energikomm_en/main.html. (published February 22nd, 2011).

took up residence was located in the area called Hosle, right close to the boundary of Oslo and Bærum municipality. My immediate neighbours and acquaintances were mainly local Norwegians, which provided more opportunities for possible observation.

1.5.2.3 Informants

The target population for this study was the indigenous Norwegians in the sampling area. The 17 participant households were primarily subjectively-chosen to meet a certain criteria, considering the time needed to collect data and the amount of energy and focus required to establish a substantial database. The sampling households were represented by a variety of general demographic information, including their employment, gender, familial status, age etc. The key informants were represented in ages from 26 to 82 and both genders were included more or less equally, with a few more women than men. As a specified number of people of certain types, the participant families in this study "were selected so that the following important categories were represented, each of which has been shown to have a strong influence on energy use behaviours" (Wilhite 2001:161):

(1) all stages in the family life cycle;
(2) both home owners and renters;
(3) type of house: detached houses, semi-detached houses and apartments
(4) type of household: one-person family, family without children and family with children.
(5) type of refrigeration appliances in use: fridge-freezers, refrigerators and freezers.

The sampled households did not include those who didn't use any type of food refrigeration appliances because of the extreme popularity of refrigerators and freezers in Norway (See Table 1). One-person household was represented in the sampling. Almost one third of the participant households were single-

person families which is in accordance to the latest report from "Statistics Norway" that up to 40 per cent of all households consist of only one person[10]. I also selected four households of different types who live in rented places because, according to Population and Housing Census 2001[11], up to 23 per cent of the households in Norway live in rented dwellings. At the time of being interviewed, these four households turned out to be young renters with the oldest being 30 years old, which was in accordance to the fact that "younger households (by oldest person in the household) own to a lesser degree than older households"[12].

In the whole sample selecting process, I categorized and subcategorized the target population as much as possible in order to achieve the generalizations from the sample to the population, and thus to avoid possible analytical bias.

1.5.3 Qualitative interviews

Data collection in the study is mainly based on ethnographic interviews (also termed as in-depth, open-ended interviews), combined with observations on the everyday lives of my neighbours and acquaintances when possible. Depending upon the research design and the aim of the study, I subjectively selected 17 households from the sampling area for the interviews. The interviews were conducted approximately within two months. The 17 interviews were carried out between informants and me privately, either in the homes of the informants or in their offices. The interviews varied in length

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[10] Statistics Norway (2011): "Population statistics. Families and households, 1 January 2010." [online]. –URL: http://www.ssb.no/familie_en/. (published April 7th, 2011).

[11] Statistics Norway (2002): "Population and housing census 2001- Almost two million occupied dwellings in Norway." [online]. –URL: http://www.ssb.no/vis/english/subjects/02/01/fobbolig_en/main.html. (published September 23rd, 2002).

[12] Statistics Norway (2002): "Population and housing census 2001- Almost two million occupied dwellings in Norway." [online]. –URL: http://www.ssb.no/vis/english/subjects/02/01/fobbolig_en/main.html. (published September 23rd, 2002).

from about 40 minutes to 1.5 hours, dependent mostly on the informants' willingness to talk. Actually, I found that most of the informants seemed to be interested in the discussion, and none of them declined to give their real names in my thesis when asked for permission.

Of all the 17 interviews, 16 were done in English and 1 was done with an English-Norwegian interpreter present since the informant speaks only Norwegian. Fifteen interviews were audio taped and transcribed for analysis while in the remaining 2 interviews, only note-taking was agreed because of certain ethnical reasons. Therefore, I tried to take as many notes as possible and during the interviews the informants were very much willing to repeat what they said whenever necessary. Immediately after the interview was over, I transcribed the whole process based on my notes and fresh memory. Apart from the interviews, I also took some notes after some casual conversations with some informants since they are my Norwegian friends. It seems that some interesting information or stories could be available when we talk in a more relaxed atmosphere.

The interviews were semi-structured around a set of general questions about food refrigeration behaviour in the household, however, the informants were welcome and encouraged to discuss relevant topics and describe or show me their own experience of cold storage at home. In this way, all prepared questions were worked into a conversational flow and informants were active to give their own motivations and explanations on the everyday use of refrigerators and freezers. The depth of information attained allowed for a deeper interpretation of complex energy use behaviours, something very difficult to achieve in a close format interview or from survey questionnaire responses. During the interviews the informants constantly provided unexpected information which revealed inspiring experiences and perceptions of the use of refrigeration appliances and, in most cases, led to a more thorough understanding of the energy use in the household food refrigeration

system. Most of the interviews (except the interviews with single-family households) were conducted with only one of the couples present because the other could not make it to the interview for personal reasons. Two of the interviews were done with both of the couple taking part in the discussion, which turned out to be very fruitful. It helped to get a more balanced picture of energy use issues in the household from the way how the couples interacted and expressed their views (Wilhite 2001:161).

1.5.4 Processing and analyzing data

The data collected from my field experience involved enormous variation in human behaviours, daily routines and cultural traditions; therefore, I followed two basic principles in the data analysis. The first was to identify the material in accordance with the research questions. As Geetz pointed out, "analysis consists, then, of matching assumed universals to postulated underlying necessities, attempting to show there is some goodness of fit between the two" (1973b:42). The second was to construct shared patterns of energy use based on various data resources. In this study, I tried to look for "systematic relationships among diverse phenomena, not for substantive identities among similar ones" (Geetz 1973b:44). While analyzing the collected information with these two principles in mind, I categorized the data according to the amount and type of refrigeration appliances that informants use in the household, something directly connected to the main subjects in this study. The category was created to relate informants' various refrigeration behaviours, routinized habits and life stories of informants and to look for shared patterns and relations.

1.6 Outline of the thesis

This paper consists of six chapters. Chapter 2 presents concepts and ways of reducing energy use through technical improvements in the household refrigeration system and further looks at the limitations of energy-efficient technologies. Chapter 3 seeks to draw attention to the thinking of a human-technology relationship in a social-material context. It tries to explore how indigenous Norwegians' routinized perceptions and experiences of using refrigerators and freezers have contributed to a change of household energy consumption. Chapter 4 examines how people in Norway have become increasingly dependent on refrigeration over the past century by exploring their expectations of comfort, convenience and food safety. It highlights some of the social, economic and cultural factors that could have fostered this growing trend in household refrigeration dependence. Chapter 5 takes up some features of a less refrigeration-dependent household and seeks to present some possible policies and institutional practices, either existing or to be developed, that might help to reduce people's dependence on food refrigeration. Chapter six summarizes the conclusions of the study.

2. Energy consumption in a technical context

Emphasis has long been laid on energy efficiency in the study of energy use. A conventional understanding of energy efficiency, according to Joseph Huber, has been formulated by industry and business as a strategy to improve the efficient use of material and energy and to "allow for further economic growth and ecological adaptation of industrial production at the same time". This idea of "efficiency revolution" has taken development of science and technologies as the key to ecological challenges (2000:269).

Energy efficiency in the cold storage system has primarily been achieved through the appropriate application of more energy-efficient refrigeration technologies. However, will the energy-efficient technologies alone lead to a deep energy reduction in the household refrigeration? This chapter looks at the concept of *ecological modernization* and shows how this technical-economical idea has permeated the work for the energy intensity in the household refrigeration. It will discuss in detail the energy-efficient policies and practices that have been put in place or are being considered, the improvements in energy-efficient technologies that have contributed to refrigeration energy reduction, and the limitations and challenges to the development of refrigeration technologies.

2.1 Ecological modernization

Conventional theories of energy consumption, either device-centered model or techno-economic approach, to some extent, bear the thought of *ecological modernization*. The concept of *ecological modernization* emerged in the industrialized countries during the early 1990s and has been developed to

"analyze how contemporary industrialized societies deal with environmental crisis" (Mol & Sonnenfeld 2000:5). In the writings of scholars in political science and sociology (Zimmerman et al. (1990), Huber (1991), Spaargaren and Mol (1992) and Jänicke (1993)), ecological modernization "deals with the institutions of modern technology, (market) economy and state intervention" (Mol 1997:140) and "offers the best option for escaping from the global ecological challenge" (York & Rosa 2003:273). Mol, an influential theorist in the environmental politics, states clearly this industrial expectation by pointing out that "the only possible way *out* of the ecological crisis is by going further *into* the process of modernization" (Mol 1995:42). His concern of "modern science and technology as central institutions for ecological reform" (Mol 1997:140) implies a tendency to reduce the consumption of raw materials as well as the emissions of various pollutants with an improvement of "ecological and economical efficiency" (Jänicke 1988:23). Mol also indentifies that the role of the state is changing in environmental policy-making, from its traditional central role in environmental reform to a role as contextually "steering" regulator. Despite the reorientation of state and market in the ecological modernization theory, one of the core features of ecological modernization theory still lies in its assumption of a harmonization of industry with ecology through the development of new and integrated technologies (Andersen & Massa 2000:337).

When applying the ecological modernization strategies (EMS) into the current efficiency revolution of cold systems, as Huber stresses, "the innovative capacities and tools of the EMS tend to be understood and used in a rather narrow sense" (Huber 2000:279). In the context of household refrigeration, the purpose of increasing efficiency is limited to achieve a relative minimization of consumption of electricity to lighten the burden on the environmental media, especially air. Industry still displays an interest in new energy-efficient refrigeration processes and equipment. Accordingly, refrigeration policies are heading in the direction of technological innovation and material recycling. I

will elaborate more on the refrigeration policy practices and technological developments in the following sections.

2.2 Policies of energy efficiency improvements

Some policies have been implemented or are being considered in Norway to improve the energy efficiency of the cold system.

2.2.1 Energy-using Products Directive

The EU Directive[13], substantially amended since its initial stages, has established a set of ecodesign requirements for energy-related products in EU countries in order to "reduce the environmental impacts and to achieve energy savings through better design". Based on the energy saving criteria in the Directive, the general principle of implementing the energy-saving measures in the cold system has laid emphasis on better compressors, more advanced insulations and a better design of stand-by mode that should be reduced to the minimum necessity for the proper functioning of refrigerators and freezers. The directive addresses the possibility of a substantial efficiency improvement for electrical appliances – "with one of the options being more efficient end use of electricity" – to achieve a significant reduction of household energy consumption.

2.2.2 Domestic energy labeling system

Energy labeling applies to all household appliances in European countries. The basic idea of energy labeling is to provide consumers with "standardized and

[13] "Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009: Establishing a Framework for the Setting of Ecodesign Requirements for Energy-related products (recast)", *Official Journal of the European Union*, 31.10.2009. [online] –URL: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:en:PDF. (retrieved April 4th, 2011).

reliable information about energy consumption and product performance" and to encourage consumers to "select and buy efficient technology" (Nordic Council of Ministers 2007:13).

Energy labeling was introduced for household refrigerating appliances in 1995 with a scale of energy efficiency "from A, green colour and low consumption, to G, red colour and high consumption". For domestic fridges and freezers, the European Commission further introduced energy classes A+ in 2003 and A++ in 2005 where A++ consumes the least energy (Nordic Council of Ministers 2007:14-15).

Norway, as one of the European and Nordic countries, has had years of experience of energy labeling schemes. The product testing department of the Norwegian National Institute for Consumer Research (Statens institutt for forbruksforskning, SIFO) is responsible for checks on the energy labeling of household appliances. According to the recent energy-labeling project in the Nordic countries, "cold appliances rated D or lower have already practically disappeared" in Nordic Market, and the lowest rating for today's fridge-freezers is Class B (Nordic Council of Ministers:2007). The result of the energy labeling scheme shows that domestic cold appliances with newly-improved compressor and insulation are becoming far more energy-efficient than before and consumers are getting more aware of the energy levels for efficiency when they choose cold appliances for their households. However, we can't deny the fact that "the energy-labeling scheme has accelerated the trend towards larger appliances" and the smaller-sized fridges and freezers have almost disappeared from the market (Nordic Council of Ministers 2007:55-57). In this sense, as Garnett pointed out, the challenge of energy-labeling lies in the fact that a large class A fridge can consume more energy in absolute terms than a smaller but class B fridge while technically the large fridge is labeled as more energy-efficient per cubic foot than a smaller one (2007:18).

2.2.3 Recycling

In May 2005, the Norwegian Ministry of the Environment published Regulations Relating to the Recycling of Waste (Waste Regulations) outlining the "reception, collection, recycling and other treatment of waste electrical and electronic equipment (EE equipment)"[14].

According to the regulation[15], fridges and freezers are defined as a kind of household EE equipment that must be recycled. The commercial sales of the cold appliances or certain certified take-back companies have the duty to accept used fridges and freezers as EE equipment free of charge when an equivalent quantity of equipment has been sold. In this sense, the regulation might have encouraged manufacturers to develop and produce cold appliances using less environmentally-hazardous materials and technology. In addition, the regulation also has a potential to encourage customers to exchange the old inefficient cold appliances with the new improved ones so that a rather quick reduction of energy use in the household refrigeration can be expected. However, up to now we cannot enforce the take-back of all used fridges and freezers. Actually, a large amount of old appliances are moved into the storeroom or basement for an *afterlife* use when new ones are purchased. According to Strandbakken, this kind of consumer behaviour "seriously threatens the perceived benefits of the efficiency revolution". This means "the introduction of energy-efficient cold appliances will contribute to the growth rather than to the reduction, of domestic energy use for cold appliances as long as this pattern prevails" (2009:149).

[14] Climate and Pollution Agency (2008): "Regulation Relating to the Recycling of Waste." [online] –URL: http://www.klif.no/seksjonsartikkel____30216.aspx . (retrived April 7th, 2011).

[15] Climate and Pollution Agency (2008): "Regulation Relating to the Recycling of Waste." [online] –URL: http://www.klif.no/seksjonsartikkel____30216.aspx . (retrived April 7th, 2011).

2.3 Novel and alternative technologies

There are many newly-developed alternative refrigeration technologies that have higher energy efficiency but lower potential CO_2 emissions. Some of these technologies have already been on the market for domestic refrigeration appliances while some are still at R&D stage for potential future applications.

The measure of merit for a refrigerator or a freezer is its *coefficient of performance* (COP) – the ratio of the change in heat at the 'output' (the heat removed at the colder temperature) to the supplied work[16]. The energy efficiency standard of the cooling can be described as following:

COP = Cooling capacity (W)/Cooling input power (W)[17]

This formula represents that refrigeration equipment of a higher COP will consume less purchased energy (electricity) than that of a lower COP in order to provide a set refrigeration capacity when given the same energy source and operating conditions. In this way, the application of higher-COP appliances in the household might lead to a smaller overall environmental impact of the domestic cold system. Some technologies that may improve the COP of cold storage appliances are listed in the section below.

2.3.1 Hydrocarbon domestic refrigeration

According to a Greenpeace[18] report in 2010, Hydrocarbon (HCs), or Greenfreeze, technology was developed in 1992 and has now been widely used

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[16] Wikipedia (2011): "Coefficient of Performance." [online]. –URL: http://en.wikipedia.org/wiki/Coefficient_of_performance#Equation. (retrived March 28th, 2011).

[17] Lee, Sun-Keun (2011): "Meps Experience in Korea." Korea Institute of Energy Research (Republic Korea). [online]. –URL: http://www.un.org/esa/sustdev/sdissues/energy/op/clasp_lee.pdf. (retrieved April 3rd, 2011)

[18] Maté, J. (2010): "Cool Technologies: Working Without HFCs – 2010." Greenpeace, USA. [online] –URL: http://www.unep.ch/ozone/Meeting_Documents/oewg/30oewg/conf-ngos/COOLING%20%20WITHOUT%20HFCs%20-%202010-GREENPEACE.pdf. (retrieved April 11th, 2011).

as refrigerant in refrigerators and freezers of various sizes with all the regular and luxury features. Hydrocarbon refrigerators and freezers use cyclopentane for the foam and isobutene (R-600a) for the refrigerant, and contain no fluorocarbons. Thus, they have a minimal direct global warming effect. Comparing to the conventional refrigeration equipment using HFCs as the refrigerant, the refrigeration COP of hydrocarbon domestic cold appliances has been reported to a mean improvement of 6 per cent (Garnett 2007:23). When applying this improvement to the energy use of refrigerators and freezers, it would result in a potential annual average saving of 420 KWh per household based on the statistics of refrigeration energy consumption in Europe in 2000[19]. The Greenfreeze technology has now dominated the domestic refrigeration market in Europe, Japan and China, and the 2010 Technology and Economic Assessment Panel (TEAP) Progress Report has predicted that "at least 75% of global new refrigerator production will use hydrocarbon refrigerants in 10 years"[20].

2.3.2 Stirling cycles

Another technological development that has potential for COP improvement in the domestic refrigeration is the Stirling cycles. "Stirling machines are energy conversion devices that operate over a closed, regenerative thermodynamic cycle" (Ross 1995:34). Stirling coolers, typically using helium or air as working fluid, "can be efficient over a large operating temperature range and are mechanically quite simple compared to other low temperature refrigeration

[19] The average savings of annual household refrigeration energy use: (495+205)*6%=420 KWh/household/year.
International Energy Agency (2003): "Cool Appliances – Policy strategies for Energy Efficient Homes", Head of Publications Service, OECD/IEA. [online]. –URL: http://www.iea.org/papers/2008/cd_energy_efficiency_policy/3-Appliances%20and%20equipment/3-cool_appliance2003.pdf. (retrieved April 1, 2011).

[20] Mat é, J. (2010): "Cool Technologies: Working Without HFCs – 2010." Greenpeace, USA. [online] –URL: http://www.unep.ch/ozone/Meeting_Documents/oewg/30oewg/conf-ngos/COOLING%20%20WITHOUT%20HFCs%20-%202010-GREENPEACE.pdf. (retrieved April 11, 2011).

systems" (Ross 1995:35). Values of COP up to 3 have been reported for temperature around 0℃, and values around 1 for temperatures approaching -40℃ (James et al. 2009:8).

The Stirling refrigerators and freezers have been successfully used in the space shuttle to store experiment samples in the US as early as 1994 (Ross 1995:38). Currently, Stirling cycles have been used for domestic and portable refrigerators and freezers of small capacity while larger Stirling cooling systems are now at R&D stage for future use (James et al. 2009:8).

2.3.3 Thermoacoustic refrigeration

Thermoacoustic refrigeration is one of the novel refrigeration technologies "that will find niche application in food refrigeration operations in the future" (James et al. 2009:8). According to Tijani et al., Thermoacoustic refrigeration systems use sound to generate cooling power and has an experimentally-evaluated cooling capacity for temperatures approaching -65℃ (2002:49). Values of its COP up to 1.0 have been reported in the experimental measurement results. The Thermoacoustic system for food refrigeration appliances is likely to be in the area of domestic refrigeration in approximately five to ten years[21] (James et al. 2009:8)

Generally speaking, refrigerators and freezers using alternative technologies such as hydrocarbon, Stirling or Thermoacoustic refrigeration, have a higher COP than the conventional standard cold storage appliances using HFCs for the refrigerant. In this way, these new energy-efficient refrigerators and freezers have a potential to result in great energy savings. However, the problem is that the technological efficiency itself is approaching some

[21] See "Table 4: Characteristics and applications of new/alternative refrigeration technologies" in James et al. (2009): "Improving the Energy Efficiency of Food Refrigeration Operations" for a review.

technical limitations and, in some cases, even the savings from technical improvements are steadily being used by "other developments occur in parallel" (Thorne-Holst & Strandbakken 2005:40). I will discuss the limitations of refrigeration technology in the following section.

2.4 Limitations of Technological efficiency

2.4.1 Technical limitations

Over the past few centuries, industrialized countries have successfully made significant gains in technological energy efficiency of cold systems. According to Strandbakken, the improvements in refrigerator technology, including cleaner refrigerants, better compressors, more advanced insulation and better design, have achieved great savings in energy use per litre. For instance, "improvements in refrigerator technology offered an 86 per cent reduction in energy per litre, from the 1972 US average to the best available technology in 1983" and "the best freezer in the Danish market in 1988 used about 64 per cent less electricity than the average then in use" (2009:147).

In cold systems, the use of hydrocarbon as an alternative refrigerant to HFCs, as discussed above, improves domestic cold energy efficiency by up to 6 per cent. Stirling cycle and Thermoacoustic refrigerator applications are claimed to have "no direct impact on the environment" (Radermacher & Kim 1996:66) and both have a potential capacity of lower temperature and a higher value of COP than conventional cold storage equipment.

All these improvements show that improved technologies have considerable effect on energy efficiency. However, we can't deny the truth that technological developments are approaching some practical limits. For example, hydrocarbon refrigeration bears the potential to become "the worse greenhouse gas emitter" (McMullan 2002:95) and consume more energy than

the conventional systems if they are not properly designed and implemented (Garnett 2007:23). The application of the Stirling cycle and Thermoacoustic technology to domestic refrigerators and freezers are still at the R&D stage (James et al. 2009:8). Currently, it is still difficult to identify, in the new technological areas, any promising technologies to further reduce energy consumption for household food refrigeration.

The technological limitations have shown that "technology is a necessary, but not a sufficient part of the solution"[22] in solving the problem of ever-growing energy consumption. However, some researchers are still hopeful in further significant gains in technological energy efficiency, especially in the end-use technologies[23].

2.4.2 Rebound effects

The technical potential for energy-efficient improvements "receives relatively uncritical support from business, environmental groups, political parties and the general public" (Sorrell & Herring 2009:2). "Technological efficiency has been regarded as an improvement in the economic efficiency or productivity in the sense of getting more out the resources" (Wilhite & Norgard 2004:994). This efficiency argument is counteracted by something called "rebound effects" (Sorrell & Herring 2009:2). In this case, energy efficiency improvements actually encourage the energy demand and in turn reduce the net effect of technical innovation.

Rebound effects, according to Steve Sorell and Horace Herring, are a range of mechanisms based on insatiable and unstrained demand for energy services

[22] Eckersley R. (Dec 10, 2010): A presentation at "Klimaoppmøte." [online]. –URL: http://www.sum.uio.no/news/news-archive/2010/12-09-klimaoppmote.html. (retrieved February 9th, 2011).

[23] See Norgard 1989, Goldemberg et al.1988, Weizsäcker et al. 1997 for a review.

that "may reduce the size of the 'energy savings' achieved" (2009:3). Rebound effects can be divided into indirect rebound and direct rebound effects.

2.4.2.1 Indirect rebound

Indirect rebound effects are often presented in a way that "consumers or manufactures save on their energy bill, but spend the surplus on other consumption or investments, which in turn increases energy consumption" (Wilhite & Norgard 2004:994). For example, money saved on motor-fuel consumption may be spent on an overseas holiday (Sorrell & Herring 2009:4).

The indirect rebound effect of refrigeration technology has the potential to "pave the way for other complementary technologies such as the microwave oven" (Wilhite 2010:7) in the household. However, it is shown in this study that only 3 out of the 17 interviewed households have the experience of using microwave ovens while all of them have at least one fridge-freezer in the household. Even if the number of households involved in this qualitative sampling is relatively small, it is safe to conclude that the introduction of microwave ovens resulting into the indirect rebound of refrigeration technology is not a common phenomenon in Norway. Therefore, more study has been focused on the direct rebound effects of the refrigeration technology in this research work.

2.4.2.2 Direct rebound

Direct rebound effects have been the focus of much research of individual energy services, such as personal automotive transport; household heating, lighting and refrigeration, etc (Sorrell & Herring 2009:23). For instance, when the cost of per kilometer driving becomes cheaper due to energy-efficiency improvements of vehicles, consumers might tend to drive more hours and for longer distances (Sorrell & Herring 2009:4). Take space heating as another example, people may keep the room warm for a longer period of time because

less electricity are consumed by energy-efficient heating appliances per square metre floor space.

The direct rebound effect plays also a factor in the household refrigeration in Norway. Today, modern refrigerators and freezers are almost five times more efficient than those in 1970s, while the use of more energy efficient refrigerators "has not resulted in a drop in energy use for that purpose to one fifth or anything close to that" (Wilhite & Norgard 2004:996). This is because the 'energy savings' from the technological efficiency has been eaten up by the increasing energy demand for more cold storage space. Although it is not likely to increase the average utilization of a refrigerator or freezer due to its steady consumption of electricity per unit, still it "could lead to a long-term increase in both the number of refrigerators and their average size (since the cost per cubic metre of refrigeration has fallen)" (Sorrell 2009:25).

In Norway, the direct rebound effect is associated with the growing number and size of energy-efficient refrigeration appliances. Currently, modern refrigerators and freezers, whether small or big, on the Norwegian market are all labeled as energy-efficient of different levels. In a recent survey on the life-span of refrigerators and freezers in Norway, the researcher found that people have a tendency to choose refrigerators and freezers of lower energy consumption but larger size although this kind of refrigerators and freezers are comparatively more expensive. From a total energy use perspective, new efficient refrigerators and freezers are less energy-consuming than the old product because they consume less energy in their lifespan (Strandbakken 2009:147-148). However, the total consumption of a large energy-efficient refrigerator definitely requires more electricity per year than the refrigerator of a smaller size although a larger refrigerator uses less electricity per litre of refrigerated space available. In addition, old refrigerators and freezers are, in most cases, still in use in the homes when new ones are purchased. Here my point is that those new energy-efficient cold appliances actually *add to* the

refrigerating capacity or the appliance population instead of merely replacing inefficient ones in the household. Therefore, the introduction of energy-efficient cold appliances actually leads to "the *growth*, rather than to the reduction, of domestic energy use for cold appliances (…)" (Strandbakken 2009:149).

Another source of the direct rebound effect in the household refrigeration lies in the relatively lower cost of electricity services. In Norway, household refrigeration services are mainly based on electricity which covers 80 per cent of the total households' use of energy. The cost of electricity in Norway is comparatively lower than that in any other European country because Norway has a very high hydroelectric component in its electricity production system. The highest price of the electricity, before 2008, has been around 1NOK per KWh[24] which include a considerable price rise on electricity during the winter 2002/2003. Electricity is still relatively cheap as compared to Norway's average after-tax income of 455 400NOK[25] per household. Over the long term, the lower cost of refrigeration services may contribute to further increases of energy-intensive appliances in the household. Therefore, fundamental changes in household infrastructures or lifestyles which imply a continued growth of energy consumption can be expected. For instance, the growing number and size of household refrigeration storage units may lead to a shift towards increasing distances between residential and food shops or a shift towards refrigeration-based food patterns, cooking patterns and shopping patterns.

[24] Statistics Norway (2011): "Table: Prices on electricity and grid rent of households (øre/kWh)." [online]. –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selectvarval/define.asp&Tabellid=08359. (retrieved February 11th, 2011).

[25] Statistics Norway (2011): "Table: Registered Incomes for Households1, by Type of Household, Average in NOK, 2008." [online]. –URL: http://www.ssb.no/ifhus_en/tab-2010-03-11-02-en.html. (retrieved February 11th, 2011).

In this way, the rebound consumer behaviour directly threatens the perceived benefits of the efficiency improvements. The energy demand will keep increasing because consumer's choices are not isolated acts of rational decision-making, but choices heavily influenced by "structural features that often make it convenient, rewarding, even necessary, to increase consumption" (Princen & Ken 2002:15).

Concluding remarks

Industrialized countries have long pressed on with efforts to prove that the energy efficiency of technologies is the most significant solutions towards ecological problems. However, we have to admit the truth that the demand for energy in these countries is keeping growing. The concept of ecological modernization is relative in the real energy reduction due to some technological limits and rebound effects. According to Eckersley, "the idea that the climate problem can be solved by technology alone is based on a false premise (...) We need to understand the everyday architecture of choices."[26] Hence, technological development is necessary, but it's not sufficient as the solutions to ecological challenges.

[26] Eckersley R. (Dec 10, 2010): A presentation at "Klimaoppmøte." [online]. –URL: http://www.sum.uio.no/news/news-archive/2010/12-09-klimaoppmote.html. (retrieved February 9th, 2011).

3. Energy consumption in a social-material context

Technologies have been regarded as both a major source of energy problems and a possible solution of global climate change. However, "whether we focus on the past, present, or future, or we compare patterns of daily life and energy consumption in different parts of the world, it is clear that energy is used by people" (Shove 1998:293) and not only by the technological instruments or devices. So human beings and how they are interacting with things or technologies in their everyday practices are significant in the understanding of energy consumption.

This chapter reviews the relationships between human factors and technologies in household refrigeration energy use, and in the process, outlines a series of routinized practices that open the possibility for energy reduction in the cold system.

3.1 Human-technology relationships

A good starting point to explore the interaction between human and technology is to understand Mary Douglas' classical statement on consumption – "The modern person is a subject made by means of objects" (Wilhite 2010: Lecture 5). This statement implies both the human acquisition as well as the use of things, thus, it conveys a double meaning and implication on modern consumption.

First, the statement suggests that objects (goods or materials) have potentials to influence subjects (people) (Wilhite 2010: Lecture 5). An important implication of this materialistic idea lies in the concept of material

embeddedness of consumption. To understand consumption in a material context, "one of the things that should be taken into account (…) is the social impact that the technology in design will have as soon as it enters society" (Verbeek 2006:361). It is of vital importance to understand the role of objects (tools or technologies in the modern world) in order to analyze the energy consumption in a material context. Heidegger claimed that "tools should be understood as connections or linkages between humans and reality" and, according to Verbeek, "they do play a constitutive role in the human-world relation that arise around them". (Verbeek 2006:364). Akrich claims that technologies bear with them "potentials, 'frameworks of action' or '*scripts*' that channel behaviour in certain (unanticipated) ways" (cited by Wilhite 2010:L4). Thus, the role of technological artifacts in their use contexts helps to mediate the human-world relationships by co-shaping human actions and experiences.

The second implication of this statement is the social embeddedness of consumption. The statement means that subjects (people) use objects (goods or materials) to understand what is happening in the world around them (Wilhite 2010:L5). In this sense, human beings, as both object producers and consumers, can actually apply various *descriptions* to technical contents of things in their social practices. The "rock example", which Wilhite gave in his lecture, can well-explain this point of view. A prehistoric man picked up a rock from the ground and accidentally used it to break an apricot. Just at that moment, a wild animal approached to him. The man instantly threw the rock in his hand at the animal and drove him away. In this process, the man, for the first time, came up to an idea that a rock could be used to crack open an apricot, and it could also be thrown to hit something. Thus, the rock was given a social value as an opener to food, and also a weapon to kill animals (Wilhite 2010:L5). This example has vividly stated that the notion of *descriptions* has to be developed by people through real practices of tools and technologies.

3.1.1 The *script* of technology

About a decade ago, Akrich and Latour introduced the *script* concept of technology to describe the roles technologies play in their use contexts. Like a film script, technical objects are inscribed, by designers, with predictions about the materiality of the product and predeterminations on how users will interact with the product (Verbeek 2006:361-362). The end product of the *inscription* by designers is termed as *scripts* (Akrich 2000:208). The *scripts* of technological artifacts, according to Verbeek, help to facilitate people's involvement with reality and "co-shape people's being in the world: their perceptions and actions, experience and existence" (Vebeek 2006:363-364). The script concept opens a new way to assess technologies with respect to their roles in human practices.

Let's take a look at the *scripts* of domestic refrigeration technologies. Refrigeration, as a method of removing heat, was initially designed for maintaining a lower temperature with the help of refrigerant within an enclosed space (Singh 2010:1035). What has been inscribed in the modern refrigerators and freezers by the designer was to maintain a lower temperature for food so that the food is fresh enough to eat. Also refrigerators and freezers of larger size have been inscribed as to provide more food storage capacity. In this sense, refrigerators and freezers of various kinds have the ability to invite people to store food in different amounts or keep food in various ways.

People will probably change their food behaviour once they have access to modern refrigerators and freezers. Inger and Tormarne, both 66 years old at the time of being interviewed, used to live in a big house with a kjølerom (refrigerated room) in the basement. According to Inger and Tornarne, this three-square-metre room with a well-insulated door and walls is specially

designed for cold storage. The room is electrically cooled at about 7℃ all year around and it has shelves attached on the inside walls for storing food. The room actually functions as a huge refrigerator. Now Inger and Tornarne live in an apartment of 121 square meters. They have altogether 3 refrigerating appliances of various kinds in their apartment: one standard refrigerator, about 300 liters, in the kitchen, one combined fridge-freezer of the same size in the small storeroom and one freezer of 100 liters in the basement. They admitted that they have been used to a life with refrigerators and freezers for quite a long time. Inger recalled her first experience of a refrigerator when she was living with her parents:

> "My father bought a fridge in, that was in the early fifties. It came from England, I think. It was so thick and so big, so heavy, but it was heaven. You have some different things to make, ice cubes, ice-cream."

Hildur, an 82-year-old lady, lives alone in a semi-detached house. She had a standard fridge-freezer of 300 liters in the kitchen and a big freezer with an open lid on the top in the basement. She bought her fridge-freezer at least 14 years ago when her husband had their kitchen refurnished, and, to my great surprise, her freezer in the basement was almost 45 years old and is still in use. She thought herself as being very lucky because her mother bought this freezer for her as a wedding present. Hildur described the berry-picking tradition in her family and also mentioned the changing preservation of berries.

> "My father-in-law had a garden with a lot of berries. My husband [died years ago] was eager to pick berries and we didn't need to buy extra jam. Before we had the freezer, we had to boil the berries with sugar. We used to make juice out of berries. That was a lot of work. After we had the freezer, we just put all the berries in the boxes and put them in the freezer (…) we didn't need to boil them. That's good for the vitamins in the berries."

Most senior people in Norway, usually over 60, have actual life experience without refrigeration appliances. According to the interviewed elderly, raw food products like meats, fish, etc are laid out on the shelves in the *kjellar* or *stabbur* (Chapter 1). Milk, eggs or vegetables for everyday use were kept on kitchen shelves or cupboards attached to the north side of the kitchen wall. Refrigerators became popular in Norway in the 1950s. Those traditional perceptions and methods of cooking and preserving food were gradually substituted by modern refrigeration technologies. Therefore, technologies, with their pre-scripted intentions, play an active role in influencing and re-shaping people's food-storage decisions.

The *script* of refrigerators and freezers has the potential to encourage people to adjust their food habit when they move from a refrigerator or freezer of smaller size to one with larger cooling capacity or vice versa. Helga, a student of 25, used to live in a student house. She described the fridge-freezer there as "very small and very old" and "actually the freezer was not working". She stated that she didn't put anything in the freezer compartment and only stored a very limited amount of food in the fridge. She had to shop every day and it was impossible for her to keep leftovers. Now she has moved out of the student house and started to live in a rented place with a fridge-freezer of around 300 liters in the kitchen. When asked about her current fridge-freezer, she seems to be quite satisfied with the capacity of the "big" refrigerating appliances in use, "All kinds of food I stored in the fridge like (…) milk, juice, um (…) dinner, like all kinds of dinner, like meat, cheese, stuff on the bread, jam, butter, ham, that kind of stuff". She agreed that the bigger fridge-freezer made it possible for her to store more food while with refrigerating appliances of smaller size she could only keep a certain amount of food for use of the same day or for the next day.

Kristinge and her husband also experienced some changes when she moved into a new rented place with their two small children. Before they moved into

the current place, they stayed in a big rented house for one year. At that time they had a 1.8-meter-tall fridge-freezer from the owner of the rented house and a 60-centimeter-tall freezer of their own. Their rented apartment now is equipped with a fridge-freezer of the same size as the one in the former rented place, but they have no room for their freezer due to limited space in the kitchen. Temporarily, they have to store the freezer in Kristinge's parents' garage. They are trying to get used to the life without their extra freezer. Kristinge's husband is really frustrated because he can't use the freezer any more. According to Kristinge, her husband fishes a lot and likes old traditional Norwegian cooking, for instance, he likes to make *fiskdeig*[27] every time he goes fishing. Kristinge told me "my husband, he fishes a lot. (…) He has to put it [fish] somewhere. (…) So our freezer is always full because of that". If her husband makes so much *fiskdeig* that their current fridge-freezer is not big enough to store, according to Kristinge, "Then he will probably take it to his parents' house where they have large compartment freezers and store it there or we will give it to someone as a present (…)" She further made some complimentary explanation on their freezer, "He [her husband] is the type that likes to store a lot of food, so he is frustrated with us not having the freezer now because then [when they had the freezer in use] he could fish and hunt more often".

These above examples well illustrate Verbeek's point that "what people do is in many cases co-shaped by the things they use" (2006:366). In Kristinge's and Helga's cases, both households live in rented places where their choices of activities are directly influenced by the changing refrigeration conditions. Kristinge's family has to adjust their food preservation habits in a situation where their total household refrigeration capacity has been reduced while Helga enjoys the larger storage volume of a bigger fridge-freezer. In addition, we can learn from Kristinge's experience that it is a tradition to distribute

[27] *Fiskdeig* refers to minced meat of fish.

caught fish and games to relatives or friends in Norway when refrigeration is not available in the household. However, the traditional distribution is disappearing with people's increasing dependence on food refrigeration because people are more likely to store their hunted food in freezers than to give them away as a gift. Hence, the refrigeration technology is not at all silent. Instead, the changing refrigeration capacity has contributed to the change of users' food habits, life styles and social relations.

3.1.2 The *description* of technology

Designers define the characteristics of their technological products and in this way they inscribe predetermined relationships between an object and its surrounding actors (Akrich 2000:208). However, the *scripts* envisaged by the designers are not fixed properties of artifacts. "They get shape within the relationship humans have with these artifacts" (Vebeek 2006:365). People, as active and creative individuals, may develop new functions of the designed technology in a surprising way. For instance, the telephone and the typewriter were interpreted in the use context as communication devices while they were initially developed as equipment to help the blind and the hard of hearing to hear and write (Verbeek 2006:365); room thermostats, in some cases, are used as on-off switches (Wilhite 2010:6). In the real use context, maybe no users will come forward to play the inscribed role of the technical objects or users may develop different identities of the objects of their own.

There are many examples of this human *description* of technology in real household practices of refrigerators and freezers. The most striking *description* can be associated with a recently-developed function of the refrigeration appliances as a backup food storage place for special occasions or social events.

Those backup refrigerators and freezers are usually settled in the basement and run all year round; however, not much food is actually stored in them except

when there is a party or when it is during holiday seasons like Easter or Christmas. Toreil, a 51-year-old lecturer in the college, lives with her husband and two sons in a detached house. At the time of being interviewed, their two sons are living in the university. Toreil showed me her extra refrigerator and freezer in the basement. Both the refrigerator and freezer were quite new and marked as energy-efficient ones. However, the freezer was less than half full with some frozen meat or fish inside and the refrigerator is almost empty with only several bottles of beer and a small pack of preserved herring. She agreed that beer and preserved herring could stay well outside the refrigerator when they were packed, but she explained that she kept them in the refrigerator because there was plenty of space. She also emphasized the importance of the storage potential of her back-up refrigerator and freezer during Christmas seasons. She told me "Though it's not very much that it [refrigerator or freezer] has to be here [at this moment], but when it's Christmas, you will have a lot of things [to store]". Another informant, Annette, 26 years old, also recalled that her mother usually made about 300 donuts and stored them in a separate freezer during Christmas. Tormarne described their refrigerated room as a kind of luxury, but useful. He expressed his satisfaction with the capacity of his refrigerated room by saying "When our neighbor, Linda, was going to have a party, she had her cakes, sandwiches and everything else and used our refrigerated room as a storage place".

The concept of social load, both base and peak (Wilhite et al. 1999:281-285) is useful in interpreting the nature of 'necessary' and 'exceptional' use of refrigerators and freezers. Wilhite et al. wrote about the daily or seasonal variation of the loads on an energy system and further pointed out "a certain amount of energy demand ('base load') can be assumed for much of the time, while relatively short term heavy demands sometimes add considerable 'peak loads' to the system". When applying the concept of social load to the household refrigeration, we can assume safely that the capacity of a refrigerator or a freezer is determined by the peak load of the energy

equipment, whether it be seasonal or daily. Obviously, it is nearly always wasteful to have back-up refrigeration equipment that is idle much of the time but maintained in a stand-by state as insurance against food shortages or unusual events. However, one does need spaces to hold large amounts of food for special social occasions such as holidays, parties and the like even though a very small unit could be sufficient for basic food preservation in the household.

In addition, from the above examples, we can see that the embedded western style of social life is, to some extent, responsible for the new roles refrigeration has played in the household. In Norway, like in any other western country, Christmas is one of the most significant religious festivals. Daniel Miller has indicated that "Christmas may be everywhere, but the only true Christmas is within one's own home" and thus family is the minimal unit of Christmas rituals such as carol singing, shopping, feasting and exchanging gifts (1993:29-30). Parties are another one of the important occasions to draw family members together, make friends and maintain social networks. Parties for various holidays and social events like birthday, start of school, graduation, wedding and even death are part of the social life in western countries. From the point of view of consumption, the most important aspect of contemporary festivals and parties lie in their materialistic embeddedness. As for consumption of refrigeration, the ritual of having a good feast of food at festivals and parties reinforces the importance of domestic cold storage devices. The household should always have sufficient refrigeration capacity for the 'peak load' of food application. Here, the materialistic embeddedness of refrigeration is full of potentials to develop new functional uses of refrigerators and freezers.

Another user's description is that refrigerators and freezers have the potential to become a place more than just for food storage. All the interviewed

household keep a certain amount of drinks such as saft[28], beer and wine in the refrigerator though these drinks can be stored at room temperature. The reason why people store drinks in the refrigerator is because they like to drink them cold. The younger ones tends to keep bottled drinks of different kinds in the refrigerators more frequently than the middle-aged and elderly people despite that they have comparatively smaller household refrigeration capacity. "It is clear that there are generational differences in food-storage practices" (Wilhite 2008:64) in Norway. However, it is safe to give a reason that the main motivation of younger people to use refrigerators as a storage space for more drinks can be considered as to save space. The younger generation generally occupies smaller residential places with less storage space than the middle-aged and the elderly generation.

In the everyday use, the more refrigeration space the household occupies, the more the household tends to change the space into a storing place for everything. The three-square-metre refrigerated storeroom Tormarne and Inger used to have in their detached house is the largest refrigerated space of all the households being interviewed. The couple described the refrigerated storeroom as a kind of luxury and extremely energy-consuming because the room needs to be electrically cooled at about 7℃ all year around. However, the couple also claimed that this refrigerated room was very useful when they lived as a household of five. They could shop only once a week and store a week's worth of food in the room. Also, the refrigerated room is big enough for everything that requires low temperature. Tornarne told me that there were shelves in the room for everything. They could have Inger's fur coat in there because the fur coat was supposed to be hung cold in the summer time.

Regardless of the original motivation, once introduced into households, the potential of refrigerators to save storage spaces or to provide a place of lower

[28] *Saft* is a kind of popular drink in Norway.

temperature have contributed to the changing practices. The embedded capacity of refrigerators to "channel practices in certain predetermined ways" (Wilhite 2008:65) may lead to different kinds of unanticipated uses.

3.2 Routines

Harold Wilhite argues that tacit knowledge and routines are important in understanding the indoor energy consumption. He writes about the routines around eating: "When I sit down to a meal I take the fork in my left hand and the knife in my right [revealing my U.S.A. origin]. I cut the food, transfer the fork to my right hand, and then move it to my mouth" (Wilhite 2010:6). For Wilhite, his action of using knife and fork while eating "happens below the threshold of conscious thought" and he could even "have some intelligent thought while performing these routinized actions" (Wilhite 2010:4). In describing the power of routines in the complex consumption practices, Wilhite makes the point that "many home energy practices are routinized. The ways we light, heat, clean, cook, commute and even shop are steeped in tacit knowledge." (Wilhite 2010:4). Wilhite's practice theory of energy consumption provides a template for theorizing how routines and energy practices are embedded in the household refrigeration and how disrupted routines may lead to a possible change of energy intensity of indoor cold system.

3.2.1 Culture-based routines

Wilhite's comparison of routines around getting food from plate to mouth in Norway and in the USA shows that "culture is agentive in practice" (Wilhite 2010:4). Also, Wilhite et al.'s comparative study of heating and lighting in Japan and Norway well illustrates this social embeddedness of *cultural energy services* (See Wilhite et al. 1996 for a review, Shove et al. 1998:307). The

study has unearthed the important symbolic value of heating and lighting in Norwegian households as the creation of what Norwegians called “koselig” (coziness), which is related to a warm and comfortable indoor atmosphere, especially in the long cold winter. Here, the conventional value of heating and lighting in Norwegian homes is to “create mood rather than brightness and to contribute to a feeling of coziness” (Shove et al. 1998:308). The case of domestic heating and lighting has demonstrated that “technology and economy are significant, but not the only or even the most important driving forces” (Aune 2007:5459) in understanding the overheating and overlighting in Norwegian homes. Household energy services are closely bound up to social conventions and practices.

Indeed, while applying this culture-based understanding of routines to household refrigeration, it is safe to say that some tacit knowledge or routinized refrigerating behaviour originated from people’s traditional way of living. The Norwegian history of benefiting from nature by hunting and fishing can be dated back to the Viking Age. Norwegians were accustomed to store food for winter because of Norway’s typical geographical location and climate condition. Traditionally, people in Norway went fishing and hunting before the winter came. Then they salted or dried the hunted fish and games into food that could be stored safely and long enough for future consumption in winter. Norway has a long history of dried, salted food, as described in Chapter 1. Today, fishing and hunting are still a significant part of people’s life in modern Norway. What has changed is people’s perception of these activities. Actually, fishing and hunting are now features of enjoyment to be close to nature rather than a necessary method to acquire food for survival.

From the view of consumption, the most important aspect of what these old-fashioned activities have influenced people’s routinized food refrigerating behaviours is how households store hundreds of kilos of fish or a whole moose when returning home. One of the most popular ways to store such a large

amount of fish or meat for a long time is to put them in the freezer. In the analysis showing their storing experience, many informants emphasized the necessity of the freezer. Kristinge's freezer compartment is always filled with her husband's homemade *fiskdeig*. Liv, an 80-year-old lady, describes that their freezer in the basement has enough capacity for the whole leg of a moose. Another possible way to store hunted fish or meat is to give them to friends or relatives as a gift. Kristinge told me that "Nobody will throw them away". In Norway, exchanging hunted goods has a social significance of showing friendliness, which has become what we call a cultural energy service. Hence, people's routinized use of refrigeration energy is deeply rooted in the cultural and social presentation of the household.

3.2.2 Moving into a place

People may change themselves into a new set of routines when they move from one place to another. According to Wilk and Wilhite, a move into a new place is full of potential to initiate "a period of intense reflection by the family over household routines" and "a flurry of home improvements" (See Wilk and Wilhite 1985 for a review, Wilhite 2010:5). These potential improvements occur when people move from one rented place to another or when they buy a new place of living. Moving leads towards different patterns of adjustments of household energy routines in the above two situations. To those households moving from one rented place to another, their life routines are, in most cases, limited by the material environment in their rented places, as discussed in chapter 3. Thus, quite limited improvements are expected. However, to those who buy a new house to live in, the move more likely involves a considerable re-modernization of the place and purchases of energy-intensive products. The following section will focus on the changing refrigeration energy intensity that results from a move into newly-bought accommodation.

Norwegians are conservative in their concern of getting a place of their own when they have managed to get a stable annual income. Generally speaking, "Norwegians view investing in property as a secure investment" (Aune 2007:5460). Almost 80 percent of the Norwegian households live in their own residential places[29]. When they buy a newly-built accommodation, they usually spend quite a large amount of money on new appliances in the kitchen. When they purchase an old house, they spend money on the maintenance, often involving "'aesthetic' rebuilding like changing the style of the kitchen" (Aune 2007:5460). After the refurbishment, new kitchen appliances are likely to take the place of the old ones. Indeed, the replacement of old inefficient refrigerators and freezers with new energy-efficient ones could have resulted in energy savings for refrigeration. However, the research on the lifespan of refrigerators and freezers has shown that more than 68 per cent of the refrigerators and 57 per cent of the freezers that worked in the households were not replaced by energy-efficient new ones but actually disposed of as back-up machines in the storeroom or basement (Strandbakken 2009:149). In the real use context, the number and size of refrigerators and freezers become substantially larger after the purchase of houses. In this sense, Norwegians' belief in their ownership of living places suggests a potential growth of energy intensity in the households. Odd Arne, aged 48 and now living alone, got his very first new fridge-freezer when he bought his apartment and had it completely refurnished. Before that he lived in rented places and only used the refrigerators there. Another informant, Otto, a middle-aged man who lives alone in a spacious detached house, bought his first refrigeration appliances when he moved into his current house in 1981. He told me:

> "I started to use the combined fridge-freezer and the freezer at the very beginning[30]. I changed to my second combined ones about ten years ago. I

[29] Statistics Norway (2010): "Population statistics. Families and households, 1 January 2010: One in five alone." [online]. –URL: http://www.ssb.no/familie_en/. (published April 8th, 2010).

[30] According to Otto, he bought a fridge-freezer and a freezer since he moved into his own house in 1981 and has never changed his style of refrigeration appliances up to now.

bought the first one around 1981 and they survived, actually 19 years. Before 1981, I used a refrigerator, not in my house, but in my father's house."

Ingrid and Erland, a young couple with two small children, are very happy with their current living conditions. They moved into their 3-bedroom apartment in 2006 when they bought it and had it completely re-modernized. Now their open kitchen is installed with a fridge of about 300 liters and a freezer of 100 liters and there is another 300-liter freezer in their basement.

Ingrid: Our first apartment was about 50 square metres. The kitchen was very small, and had a small refrigerator.
Min: What kind of refrigerator was it?
Ingrid: It was a tiny combination one with a small fridge on the top and a small freezer at the bottom.
Min: Could you describe the routines of how you used the small fridge-freezer?
Ingrid: It's just very small. I can't quite remember the routines when we used the small fridge, but I did go shopping more often and couldn't buy much food because there was not enough space to store the food.

According to Ingrid's description, the total household refrigeration capacity in her household has almost tripled after the move and their routinized food shopping and storage patterns have changed accordingly.

Examining the energy-intensive refrigeration appliances in these interviewed households, the move into a new place suggests an increasing number of refrigeration appliances in the household. The accompanying adjustment of routines before and after the move might also open the possibility of a growth of indoor energy consumption.

3.2.3 Events in the life cycle

Household routines get disrupted in conjunction with family events in the life cycle such as marriage, divorce, the birth of children and later when children

move out of the home (Wilhite 2010:5). This section analyzes how these life changes are implicated in consumption.

3.2.3.1 Marriage and divorce

Marriage requires the married couple of different life experience and family background to live together. In this process, new couple's routinized habits in their former family life are inevitably to be replaced by the routines in the new household. Thus, marriage involves an important reinforcement of energy intensity change in the household. Unlike the situation in eastern culture where marriage is characterized as a significant social exchange of goods, money and property within the family networks of both the bride and groom (Wilhite 2008:79), a Norwegian marriage tends to be more like an engagement of the bride and groom living together. When asked about her household refrigeration routines when she and her husband move together, Kristinge told me that "we have had quite a lot of discussions over which vegetables we should keep in the fridge and which should be kept at room temperature". She described herself as getting used to "put everything in the refrigerator" while her husband "comes from a home where they have had much more different things stored in different places". She mentioned that "most people in Norway just put everything in the fridge because they are so afraid of their food getting bad, but not all food should be kept in the fridge" and she talked about the food storage function of the basement in her husband's family in particular. In the end she made the point that "we have come to an agreement". Now there is a new set of food storage routines in Kristinge's family about what food should go into the fridge or freezer and what should be kept at room temperature.

Another possible factor that may lead to different refrigeration energy consumption when marriage occurs is that when younger couples' move into their own residential home, this requires a sizable purchase of energy-intensive

appliances, among which refrigerators and freezers are usually of first priority. When Kim and Xin got married, they had their one-bedroom apartment refurnished. They bought a new Whirlpool fridge-freezer of about 19 cubic foot. The wife describes the refrigerator as "a must in daily life" and that's why they had it installed in the kitchen before the dishwasher and washing-machine.

Divorce is another change impacting energy consumption. Norway has a high divorce rate compared to other European countries. Statistics show that the rate of divorces in Norway has been as high as 12.3 per thousand married in 2003[31], even higher than the divorce rate on the United Kingdom in 2008 which is 11.5 per thousand married[32]. The number of divorces in Norway has been at the same high level for the last four years and almost 50 per cent of the total number of annual marriages was dissolved by divorce[33]. The divorce initiates a negotiation of the distribution of household properties between the couple. Ultimately, each side obtains a certain amount of money or goods and then starts to live separately. Hence, once a couple gets divorced, the number of households is doubled. The start of a new household suggests new consumption practices that should meet the demand standard that the divorced couple has got used to. In this way, these consumption routines developed in the former household of the divorced are eventually transferred to the everyday practices in their new homes. As Annette expressed in the interview, her mother took the freezer and her father had the fridge when they got divorced. Her mother bought a new fridge soon after she moved into a new place. Annette recalled that her mother must buy a new fridge because they used to

[31] Statistics Norway (2004): Population statistics, Divorces and separations, 2003: Divorce rate continues to climb. [online]. –URL: http://www.ssb.no/en/ekteskap/arkiv/art-2004-09-02-01-en.html. (published September 2nd, 2004).

[32] Wikipedia–The Free Encyclopedia (2011): Divorce. [online]. –URL: http://en.wikipedia.org/wiki/Divorce#cite_note-31. (modified April 20th, 2011).

[33] Statistics Norway (2011): Population statistics, Marriage and divorces 2010: Few marriages. [online]. –URL: http://www.ssb.no/ekteskap_en/. (published February 24th, 2011).

have a fridge and a freezer in the household and her mother couldn't manage her daily life with only a freezer at home. Just imagine if Annette's father shared the same idea with her mother, most probably he would get a new freezer at home. Thus, it turned out to be two fridges and two freezers which definitely increase the energy intensity in total.

3.2.3.2 Having children

The disruptions of routines occur "in conjunction with the birth of children, and later in the life cycle when children move out of the home" (Wilhite 2010:5). During these periods of disruption, people tend to have a possibility to adjust the refrigeration capacity in the household, by either increasing or reducing the number or size of the refrigerators and freezers or substitute the old refrigerators and freezers with new ones. Ingrid told me that her family was concerned about a bigger apartment with larger refrigerators and freezers when they had kids. She said, "When we have kids, we need more space" and "we need more space for food" and she is quite satisfied with her current refrigeration capacity in her home because she thinks that "the food is expensive" and "I can buy a lot and store them in the fridge and freezer when some food is on sale".

Toreil told me in the interview that she used to store bottles of fresh milk in their fridge every day because her sons' habit of drinking quite a lot of milk. At the moment her sons are living in the university, so she has only one carton of milk in the fridge. But she has also told me that she will get enough milk ready when her sons come home.

A couple in their sixties, Inger and Tormarne sold their big house with a refrigerated room in the basement and moved into a 2-bedroom apartment years ago when all of their three sons moved out. They said that it was very comfortable to have a large refrigerated room when the children were in the house, but they said, "Now we would worry about it if we still had that house"

because they think that “it’s a waste” and “the electricity is expensive”. That’s the reason why they moved into a smaller apartment. Now they have one 300-liter fridge in the kitchen and one fridge-freezer of the same size in the store-room and one freezer about half the size in the basement. They admit these refrigeration appliances are still quite a lot for two people, but they are more concerned about the back-up food for their children and grandchildren although all of them have moved out. Inger told me:

> “We have six grandchildren in Oslo and two in Korea and they are staying here a lot. (…) Three big ones are grown-ups. (…) If they come from school and they are hungry. (…) They can have a pizza and do homework in peace and quiet. So I always have two or three extra pizzas in the freezer downstairs. Also cakes, like the other day I made an ice-cake for Christmas. Everybody came and everybody liked that. They all love my homemade ice-cakes. I made big ones and put them in the freezer and then it’s done.”

A review of the refrigeration adjustment above has shown that the refrigeration potential in the household is closely related to the number of children in the family. Younger couples have a tendency to acquire more space for food after the birth of children, and thus they tend to install more refrigerators or freezers when they move into larger houses. Older generations are more likely to reconsider their refrigeration routines when children move out because of some practical limitations such as the cost of energy intensity in the household. It is also clear that their ideas and energy-consuming habits are changing slowly and modestly over time.

Concluding remarks

Akrich writes that technology should be reinserted into an anthropological analysis of energy consumption because “technical objects and people are

brought into being in a process of reciprocal definition in which objects are defined by subjects and subjects by objects" (Akrich 2000:222). The evidence from this qualitative study affirms the relevance of this social-material understanding of consumption. Interactions, continually occurring between the world inscribed in refrigeration appliances and the world described by the real users of the appliances, have provided a template in the mediation of all kinds of refrigeration-related consumption. Tacit knowledge and routines are also forms for consumption in that they involve the acquisition of energy-intensive household appliances (Wilhite 2008:88). The most consuming units in the household cold system are refrigerators and freezers. The increasing number and the size of the refrigeration appliances in the Norwegian households are deeply related to people's perceptions of their traditional lifestyle, their energy demand when moving into new places and their real practices in important life cycle events. Thus, the acquisition of more refrigeration goods is a social process rather than merely an individual's decision in which "a logical expert defines a more efficient solution through a process of research and demonstration and the consumer adopts it and applies it when it is in his or her economic interest to do so" (Ehrhardt-Martinez 2008:7).

4. The growing household refrigeration dependence

Hackett and Lutzenhiser describes the widely-accepted quote “a proper use for money” as “one will enjoy, want, come to take-for-granted daily hot showers followed by cold drinks or gas heating and electric cooling of entire dwellings, or the consumption of leftover food” (1991:467). Their description of a set of routines points directly towards a social-scientific viewpoint on consumption: what people actually consume in their daily life is not energy itself, but energy services (Wilhite et al 2000). Hence, their illustration has further suggested that energy consumption is socially embedded.

The energy services in the household food refrigeration indicate the significance of three middle-ranged concepts: comfort, convenience and safety. Understanding how and why these services are growing in a social-material context, it is essential to make headway on developing instruments for the reduction of people’s energy demand in the cold system. In this section, I will look at why people’s demand for these energy services has kept growing since refrigeration became mainstream in Norway and how Norwegians turn to be so dependent on food refrigeration in their lives.

4.1 Comfort

In the past two centuries, the definition of comfort has experienced some key developments, starting from its original meaning of “mental or physical strength, encouragement or consolation” (Heijs 1994:43) through to its modern redefinition as “self-conscious satisfaction with the relationship between one’s body and its immediate physical environment” (Crowley 2001:142). Crowley’s recent presentation of comfort as “wide, and in large part discretionary, social

variations in consumption patterns regarding heating and lighting" (Crowley 2001: x) is commentated by Shove as an attribute of comfort that "has been converged around a remarkably narrow specification of normal and appropriate conditions indoors" (Shove 2003:26).

In order to understand how and why we have come to be so dependent on food refrigeration, it is of vital importance to look at some comfort-oriented changes in household design, domestic ambient heating and food tastes.

4.1.1 Household design

Larder, food cupboard and *kjellar* were popular food storage devices in the household in Norway at the start of the 20th century, as described in Chapter 1. These natural food storage devices are disappearing hand in hand with the construction of newly-designed homes and have eventually been replaced by modern refrigerators and freezers in the kitchen.

4.1.1.1 Living space

Larger houses are normally considered as more comfortable living places than smaller ones. Throughout the postwar period, Norwegians' desire for more spacious residential places has been expanding and the dwellings in Norway have become more spacious. In 1950 there were 3.4 residents per dwelling and the figure was 2.3 in 2001.[34] The dwelling area has gradually increased over time, from 101m^2 on average in 1980 to 119 m^2 in 2006, even when the household size has decreased[35]. Up to 2008, around half of the total

[34] Statistics Norway (2002): "Population and housing census 2001: Almost Two Million Occupied dwellings in Norway." [online]. –URL: http://www.ssb.no/english/subjects/02/01/fobbolig_en/main.html. (published September 23rd, 2002).

[35] Statistics Norway (2008): "Husholdningenes energiforbruk: Vi bruker mindre energy I hjemmet en før." [online]. –URL: http://www.ssb.no/ssp/utg/200804/10/. (retrieved April 20th, 2011).

households in Norway live in detached houses[36]. This trend of higher dwelling area implies growing energy intensity per household, for instance, more energy needs for heating and refrigerating purposes.

It is obvious that larger living spaces imply more energy demands. According to Statistics Norway, households in farm houses and detached houses use more energy, followed by households in semi-detached houses, and the flats consume the least energy[37]. Of course, the difference is due to various energy-consuming actors in the household. However, there are usually more electrical appliances in large houses than in small dwellings[38]. I have found in my study that it is the size of the living space rather than the size of the household that has most influence on the number or size of the refrigerating appliances. Six of all the interviewed households have experience living in their own detached or semi-detached houses with at least four bedrooms. The number of residents in these dwellings ranges from one to five respectively. However, the total number of the refrigeration appliances or the total refrigeration capacity in all these households is almost the same – with one or two fridge-freezer or fridge of about 300 liters in the kitchen and an extra freezer in the basement. The rest of the households living in smaller apartments usually have one fridge-freezer installed in the kitchen. Hence, households occupying more living space are potential buyers of more refrigerators and freezers. Therefore, the size of households' living space is responsible for more refrigeration energy demands in the real practices.

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[36] Statistics Norway (2011): "Construction and Housing." [online]. –URL: http://www.ssb.no/english/subjects/10/09/bygg_en/.(retrieved March 21st, 2011).

[37] Statistics Norway (2008): "Energy consumption per household, 2006: Still low energy consumption in households." [online]. –URL: http://www.ssb.no/english/subjects/01/03/10/husenergi_en/main.html.(published April 19th, 2008).

[38] Statistics Norway (2008): "Energy consumption per household, 2006: Still low energy consumption in households." [online]. –URL: http://www.ssb.no/english/subjects/01/03/10/husenergi_en/main.html.(published April 19th, 2008).

4.1.1.2 Kitchen

The kitchen was traditionally considered as "housewife's arena for household work", especially for cooking activities (Hage 2007:29). Hage recorded two main Norwegian kitchen plans after the World War II, aiming to create a more comfortable working place for women as the family housekeeper: one type is a modern laboratory kitchen, smaller in size, with ventilated cupboard for food storage; the other is an old-fashioned large main-room kitchen, modeled from the houses in the countryside, with a dining-table and a larder (2007:31-34). After several decades, either the ventilated food cupboard or the larder has disappeared in the plan of today's kitchen, as a replacement, we can find deliberately designed space for modern electrical appliances such as a dish-washer, washing-machine and refrigerators or freezers in the kitchen.

The changing design of the kitchen has inevitably increased the energy demands in the household. Refrigerators or freezers have become a must in the kitchen. One of my informants, Odd Arne clearly remembered the "food cabinet" in the kitchen before he re-modernized his apartment.

> "The thing was that before I moved in, they had never done any proper refurbishment on the flat. Very much the arrangements, especially in the kitchen, were almost like what was in 1930. So (…) then on the wall (…) the outside wall was a kind of ventilation conduct and inside this ventilation conduct was cabinet, looking like a fridge. That was actually used as a fridge because it had the same cool air as outside. So in the old days they had a special cabinet connected outside and was used as a kind of fridge."

He showed me the right location of the cabinet and told me that the cabinet worked very well in the winter time, but he was not sure how it worked in the summer time. The ventilated cabinet was removed during his refurbishment of the kitchen and the same area was saved for his new fridge-freezer. Obviously, in terms of food refrigeration equipment in the kitchen, consumers believe that the refrigerator would function far better than the food cabinet.

Findings in the study also show that sometimes people are quite restricted in their energy decision-making. Inger and Tormarne moved into their current apartment about two years ago. They told me there was already an open area left for a refrigerator between the kitchen wall and the cooking counter when they moved in. “We could not leave it open”, as Inger said to me, so they bought a new energy-efficient fridge well fit for the space. Their experience has demonstrated that it is not just people’s changing perception of a comfortable, modern kitchen, but today’s standard design of a modern kitchen, in the absence of alternative arrangements that might have resulted in residents’ energy-intensive purchases necessary.

4.1.2 Domestic ambient heating

It is known to all that “the warmer the home, the more likely the food is, if unrefrigerated, to spoil” (Garnett 2007:43), so it is helpful to explore one of the indoor comforts – domestic ambient heating to get a better understanding of people’s dependence on refrigeration.

The average internal temperature has risen considerably in European countries since 1970s because people tend to spend their days in an environment that wavers little around 22℃and that is what they consider as a comfort condition (Humphreys 1995:10). According to Garnett, the mean indoor temperature rose 6℃ between 1970 and 2004 and a continuous increase up to above 21℃ can be expected. “A substantial proportion of Swedish homes are heated to as high as 23℃” (2007:44). Norway, as one of the Nordic countries, has long cold winters and moderate summers, so there is no reason to believe that the Norwegian trend of indoor temperature is different to the rest of other countries in Northern Europe. In as early as 1991, Wilhite already recorded in his study on household energy use behaviour in Norway that the space heating

season in Oslo usually lasted as long as six months, from mid-October to mid-April and the average winter evening living room temperature was 21.8℃ (Wilhite et al. 2001:165). Today, the statistics from my open-ended interviews show that the majority of the interviewed households have their thermostats set at a temperature ranging from 20℃ to 22℃, with one household having their thermostats set around 23℃. Therefore, the average room temperature is almost the same as it was in the early 1990s. Norwegians are likely to heat all their rooms in the houses except basement. The average temperature of a Norwegian kitchen is likely to be around 21℃, a room temperature too warm for perishable food such as vegetables, dairy products and fish or meat. Hence, refrigerators and freezers, apart from those back-up ones in the basement, have become a daily necessity in a well-heated kitchen.

The evidence from the interviews in my study also suggests that the average indoor temperature in Norway bears the potential to keep growing though it, to some extent, has been stabilized since 1990s. Women tend to keep the room temperature higher than men in all ages. Most of the female informants enjoy a room temperature of 22℃ or above while all male informants suggest that a comfortable room temperature should be around 20℃. Ivar, a 42-year-old man, told me that

> "the indoor temperature of my house is usually 22℃. I think 22℃ is too warm and I prefer 20. But my wife prefers 22℃ and I have to compromise. We keep the room temperature steady. Now we can put food in the fridge, so it's ok to keep the room warm."

According to Ivar, refrigerators make it possible for a warmer room temperature. In addition, his description implies a distinct gender difference in the definition of a comfortable room temperature. Generally speaking, females are accustomed to a room temperature of one or two degrees higher than males. In addition, wives, as a decision-maker of most of the household

routines, usually have the final say of the internal household temperature. Therefore, a gender-dependent tendency of increasing domestic ambient temperature could still be expected in the coming years.

Another possible threat to a rising indoor temperature lies in the growing income of younger groups. Comparatively speaking, younger Norwegians, especially students, live on lower economic income. Thus, the energy price is one of the major concerns for them to make energy use decisions. Helga is a university student and she feels that "20℃ is a nice temperature" because "I will not be freezing". However, when asked about her preferred room temperature, she told me that she could have the thermostat set at 25℃ "if it wasn't for the price [of electricity]" and she thinks "if I have more than 20℃ (…) the price will be more expensive." Here, people's decisions on how to use energy rely a lot on how much they can afford. Once the younger generation earns well enough to cover an electricity bill for a higher energy consumption, it is likely for them to turn up the thermostat.

From the above analysis, it is reasonable to conclude that a trend towards a female-defined higher indoor ambient room temperature as well as a growing domestic energy expenditure for younger families bear the possibility for an increasing refrigeration demand in the household.

4.1.3 Food preferences

What kind of food are Norwegians more likely to eat today compared to a half century ago? Is such food more refrigeration-dependent?

A very brief description of Norwegian household consumption of food from 1950s up to now is available in Figure 1. Detailed records of consumption of various food groups only go back to the 1970s (Table 2). It is obvious that people's consumption of refrigeration-dependent meat products increased considerably during the period when refrigerators and freezers gained their

popularity after World War II in Norway. During almost the same period of time, the per capita consumption of potatoes experienced a sharp reduction. This decreasing trend of potato consumption in the Norwegian diet, with occasionally short-term rises, has been continuing up to now.

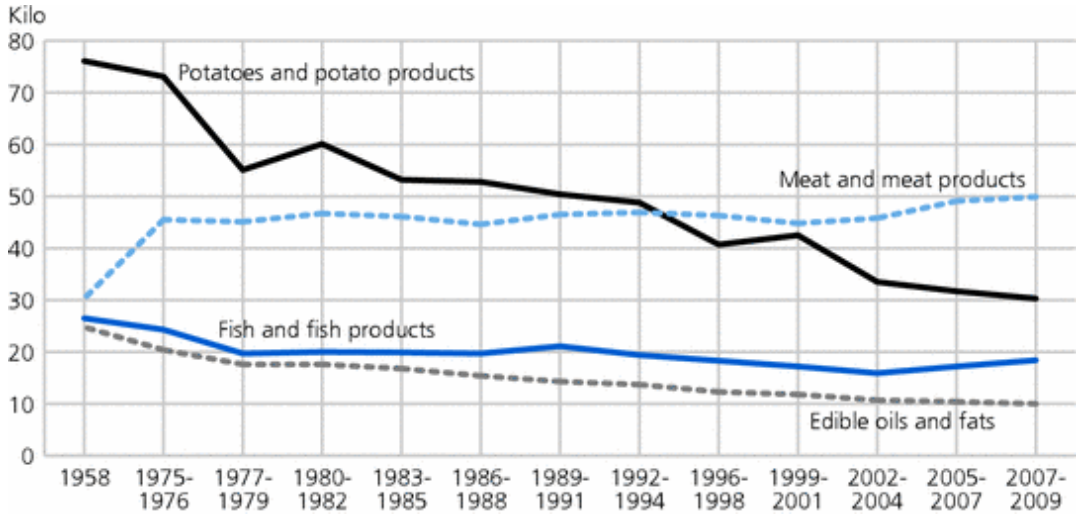

Figure 1: Consumption of Certain Food and Beverages per Capita per Year. (Kilo)

Source: Statistics Norway (2010): "Survey of Consumer Expenditure." [online]. –URL: http://www.ssb.no/en/yearbook/fig/fig-201.html. (retrieved June 6th, 2011).

From 1975 onwards, the Norwegian government started to collect detailed data on consumption of individual food items in the household. Comparing the food that we ate about 40 years ago (when refrigerators were already widely spread in Norway and freezers were only available to half of the population) with the food we buy today reveals interesting changes (Garnett 2007:45).

Table 2 shows the detailed trends of per capita yearly consumption of some foods and beverages that require refrigeration. Those temperature-sensitive foods include meat, fish, dairy products and vegetables. Potatoes are not included in the vegetables, but listed as an individual food item for comparison. Canned foods and cooking oils that can be stored at room

temperature are excluded from the table. Beverages are listed as juices, soft drinks and alcohol such as wines and beers.

Table 2 Trends of consumption of food and beverages per capita per year (kg/liter).

	1975 -1976	1986 -1988	1996-1998 / 1997-1999*	2006 -2008
Meat and meat products (excluding canned meat)	43.3	42.3	43.5	50.8
Fish and fish products (excluding canned fish)	21.9	17.8	17.2	17.7
Milk, cheese and eggs	189.6	174.3	134.1	115.5
Oils and fats (excluding cooking oils)	20.4	15.5	12.3	8.6
Fresh fruits	48.7	46.7	47.3	57.9
Fresh vegetables (excluding potatoes)	27.5	27.2	30.9	39.1
Potatoes	71.4	49.9	36.1	25.8
Edible ice and Ice-creams	3	4.1	5.3	7.7
Soft drinks	:	:	62.9*	64.8
Fruit, vegetable juices	:	:	24.8*	27.6
Wines and spirits	3.2	4.5	6.6	13.4
Beer	15.4	18.9	20.1	26.6
Total	**444.4**	**401.2**	**441.1**	**455.5**
Total Excluding Drinks	**425.8**	**377.8**	**326.7**	**323.1**

Source: Statistics Norway (2011): "Quantity consumption of food and beverages per person per year, by commodity group (kg/liter), 1958-1959 – 1996-1998." [online]. –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selectvarval/define.asp&Tabellid=06376. (retrieved June 6th, 2011); Statistics Norway (2011): "Quantity consumption of food and beverages per person per year, by commodity group (kg/liter), 1997-1999 – 2007-2009." [online]. –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selectvarval/define.asp&Tabellid=04886. (retrieved March 6th, 2011).

Note: the table aggregates food items recorded in the data bank of Statistics Norway. All canned food stuffs and cooking oils are excluded from the figures given in the table. The records of the consumption of soft drinks and fruit, vegetable juice were available from 1996.

* The figures of year group 1997-1999 were available instead of that of the year group 1996-1998.

Taking a close look at Table 2, we might come to a surprising fact that the total individual consumption of food is actually declining when beverages are excluded. The purchase of some refrigeration-dependent foods such as meat, fresh vegetables and fruits and ice-cream is growing. This is mainly due to the fact that the amount of dairy products we consume today has been through a

substantial decrease to only 3/5 of the total that we consumed forty years ago. In addition, fresh dairy products such as milk, cheese, butter and margarines can be easily bought in the local supermarkets every day and hence they require less refrigeration than before. If dairy products are not included in the table, the consumption trends of refrigeration-dependent foods go up again.

As for drinks, according to Table 2, the individual purchase of alcohol has increased significantly in Norway in the past half century. The consumption of soft drinks, fruit and vegetable juices are recorded since 1996, and it has also showed an uptrend. Although drinks can be stored at room temperature and then refrigerated just an hour or two before being consumed, this is not true of all drinks in the real user context in Norway. In my study, all interviewed families have a certain quantity of drinks stored in their household and all their drinks are consumed chilled. Over 80 percent of the interviewed families actually keep their beers, wines, juices and soft drinks all the way in the fridge while only three families store drinks in the basement or storeroom and prefer to have them refrigerated for hours or a day or two before drinking. When asked why they like to put drinks in the fridge, all of the households unanimously emphasize the importance of having their drinks *cold*. Annette told me that "we put juices and cold water in the fridge because the water from the tap is not cold enough. I prefer to drink even colder water". Ivar, a middle-aged man, described his preferences of refrigerated drinks as:

> "I like drinks to be cold, but I don't like ice cubes in the drinks, especially in no sugar drinks. If I pour the drinks into the glass with ice-cubes, the ice will make too many bubbles and the bubbles will come up. I don't like that taste."

Otta Arne said that "When I drink beer, it should be cold". All of the above informants insist that beers, white wine juices and soft drinks should be drunk chilled because they taste better. As to red wine, only one household stores it

in the fridge while the rest prefer room temperature because, as Helga told me "I have learnt that you should store it [red wine], like, in the cold place, but not that cold". The preference of the *cold* taste of the drinks and alcohols in the personal accounts, in fact, adds to people's food refrigeration-dependence in the household.

The data from Statistics Norway for fresh vegetables and potatoes also reveals interesting trends. According to the historical data in Statistics Norway, the consumption of highly perishable and refrigeration-dependent vegetables, including leaf and stem vegetables (e.g. green vegetables), vegetables grown for their fruit (e.g. squashes) and root crops, non-starchy bulbs and mushrooms, have been more than tripled[39]. Obviously we eat more fresh vegetables that need refrigeration today than before at the expense of other less refrigeration-dependent ones.

Our consumption of less refrigeration-dependent potatoes has been reduced by almost 60 per cent. Potatoes used to be the main diet in Norway, especially in winter when other types of vegetables are hardly available. Potatoes can stay for quite a long time, even for the whole winter, if they are stored properly. Otto still clearly remembered his grandparents' potato container in their basement. He told me:

> "They will buy, for example, enough potatoes to fill up a container (…) I remember from my childhood, the container is about, say one and a half meters by one meter high and one meter deep that will be filled with potatoes. Then, they will have potatoes for the whole winter. If it is dark and relatively cool, the potatoes will be able to survive."

[39] Statistics Norway (2011): "Quantity consumption of food and beverages per person per year, by commodity group (kg/liter), 1958-1959 – 1996-1998." [online]. –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selectvarval/define.asp&Tabellid=06376. (retrieved June 6th, 2011).
Statistics Norway (2011): "Quantity consumption of food and beverages per person per year, by commodity group (kg/liter), 1997-1999 – 2007-2009." [online]. –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selectvarval/define.asp&Tabellid=04886. (retrieved March 6th , 2011).

Liv, 80 years old, still keeps a bucket of potatoes in her basement for winter consumption every year. Hildur, 82 years old, told me that she only stores potatoes in the basement because “if I put them in the fridge, they [potatoes] will turn to be sweet. That spoils its [potatoes’] taste”. While the older generation prefers the traditional diet and storage of potatoes, younger groups tend to eat more new and baby potatoes that require refrigerating. Younger ones get used to keeping those kinds of potatoes in the fridge, taking little or even no notice of the taste of the potatoes. The decreasing popularity of potatoes and its counter-intuitive trend of other fresh vegetables in the Norwegian diet should be taken into consideration as one of the major contributing factors to the growth of people’s food refrigeration dependence in the household.

The data also shows a general growing trend in fresh fruit consumption. Of course, many of the fruits are not stored in the fridge, in particular bananas. Of all the interviewed families, only two store bananas in the fridge because of the *cold* taste. They don’t care about the banana turning black in the lower temperature, which is actually the major concern of other households who leave bananas at room temperature. One informant keeps all the fruits on the kitchen table instead of in the fridge because she likes the pretty display. However, we can’t deny the fact that the fruits we choose today, excluding bananas, are turning to be more temperature-sensitive.

One might question the reliability of increasing energy use of household refrigeration accompanying the changing food choices because refrigerators and freezers are always plugged in once they are purchased. There should be no difference if we put in one more beer or another melon. However, the point is the growing trends towards a diet of temperature-sensitive food might require a larger refrigeration capacity for fresh food in the household, and thus,

encourage people to buy more refrigerators or freezers or choose refrigerating appliances of larger size.

4.2 Convenience

Convenience, like comfort, can be considered as "one of the meta-energy services" and it is important "in analyzing how and why, and for what purposes people use energy" (Wilhite et al. 2000:115).

It is only recently that convenience has been defined as something to do with the management of time (Shove 2003:171). Warde et al. pointed out that the 20th century has become a convenience-obsessed society, in which everything is arranged in order to save time (1999). Understood in this way, domestic appliances are classed as convenient when they allow users to "store" time, for instance, refrigerators, freezers, ovens and microwave cookers make it possible for people to "prepare and eat a meal at a very short notice" (Shove 2003:171). This time-saving aspect of convenience has implications for energy use because "hypermodern" convenience offered by technologies and devices implies "more activities, more devices to manage the pressures of time, more traveling and greater demand for faster means of getting from one place to another" (Wilhite et al. 2000:116). In the household refrigeration, the notion of time management is closely related to the role of women and the way of shopping and cooking in the family.

4.2.1 Working women

From 1971 onwards, there has been a dramatic increase in the percentage of women who entered the workforce[40] in Norway. The employment rate for women is among the highest in European countries. In 2001, almost 73.8 per

[40] Statistics Norway (2002): "Time use survey 2000: More time for leisure activities." [online]. – URL: http://www.ssb.no/tidsbruk_en/main.html. (published May 13th , 2002).

cent of the Norwegian females were employed[41] and today there are almost as many women as men in paid work[42]. The result of more working women at the household level is the ever-increasing income to spend but less time for housework such as washing, cooking and shopping, etc (Garnett 2007:34). More men are actually taking part in housework like food preparation[43]. However, women, compared to men, are still responsible for most of the housework[44]. Hence, Norwegian women encounter a double pressure associated with housework and income-producing work. They have to keep a good balance between the time spent at home and in the office. The time pressure that Norwegian women encounter and the ways they manage the pressures are implicated in energy consumption of food refrigeration.

As to household food preparation, Norwegian households spend much less time for meals today than in the early 1970s[45]. That is to say, the time women spend on shopping and cooking food has reduced considerably. The need for quick-meal preparation and long-term safe food storage enhances households' "rapid intensifying love affair with all things technological" (Garnett 2007:34). Refrigerators and freezers, therefore, have become widely accepted as one of the kitchen necessities in Norwegian households.

Ingrid and Erland's purchase of extra freezers gives insight into a better understanding of the time pressure for working women, especially for those with small kids. Ingrid and Erland are married and have two kids, a boy 6 years old and a girl 3 years old. Both Ingrid and Erland have full-time jobs.

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41 Statistics Norway (2011): "Labour Market Statistics: Norway and EU: High employment rate for women in Norway." [online]. –URL: http://www.ssb.no/english/magazaine/art-2002-10-25-01-en.html. (retrieved March 10th , 2011).

42 Statistics Norway (2011): "Gender equality." [online]. –URL: http://www.ssb.no/likestilling_en/main.shtml. (retrieved March 10th, 2011).

43 Statistics Norway (2002): "Time use survey 2000: More time for leisure activities." [online]. –URL: http://www.ssb.no/tidsbruk_en/main.html. (published May 13th , 2002).

44 Statistics Norway (2011): "Gender equality." [online]. –URL: http://www.ssb.no/likestilling_en/main.shtml. (retrieved March 10th, 2011).

45 Statistics Norway (2002): "Time use survey 2000: More time for leisure activities." [online]. –URL: http://www.ssb.no/tidsbruk_en/main.html. (published May 13th , 2002).

Ingrid emphasized her need for an extra separate freezer in the kitchen because she can store some fast food there as back-up food when she is too busy and hasn't enough time to cook. She described it as "just for convenience". She also talked about how convenient it is to have a large freezer in the basement when she shops for quite a lot of food. Of course, other factors such as the price of the food may have an effect on how much people would like to buy at any one time. However, the time pressure on food preparation is still one of the major driving forces to households' habit of buying in bulk and storing large amounts of food in the freezers. The potential of refrigerators and freezers to keep foods of various kinds in bulk allows "the competent housewife to order her daily routine; to cook at her convenience; to plan trips to the supermarket; and to maintain and manage a much greater variety of meals or ingredients ready and available for consumption all year round" (Shove and Southerton 2000:308).

4.2.2 Shopping patterns

What do shopping patterns mean for refrigeration dependence? Garnett has argued that "how often we shop for food and how much we buy at any time will clearly have a bearing on refrigeration needs" (2007:37). As highlighted above, the shift towards shopping for more fresh but perishable food actually causes people to buy more refrigerators or buy refrigerators of larger size. Shove also pointed out the ever-growing need for domestic freezers since the mid-1970s because freezers "made it possible to beat the seasons" and allow consumers to "buy in bulk" (2003:176-177). Hence, what people actually depend on is not refrigerators or freezers, but the convenience provided by the refrigerating technology.

One change towards a refrigeration-dependent shopping time in Norway is the shift from daily or at least frequent shop for food to the weekly purchase. The data from Statistics Norway has shown that the time which people spent on

purchases per day has been cut down to about 80 percent of that in 1980 and in 2000 only one out of three people actually buy groceries on an average day, spending 24 minutes on such purchases[46]. This is unsurprising in a car dominant and refrigeration-dependent society.

People's preference of a shrinking shopping interval may directly lead to more dependence on food refrigeration in the household. Helga moved out of the student apartment where only one small freezer is available into her current residence where a large fridge-freezer is available. Now she can probably buy once or twice a week instead of going shopping almost every day. She feels free from the life with only small refrigerators available and she is happy about having a lager food refrigeration space. Annette and her boyfriend live in Oslo center, with food shops within walking distances. They go shopping quite often, usually on their way home and she thinks it is convenient to buy food because the shop is very close to their apartment. However, she told me that she preferred to go shopping once a week but "our refrigerator is so small (…) it is difficult to put into practice now". As described, shopping once a week for food is a better choice to Annette. Annette is not the only one to hold this idea of weekly shopping. Almost 60 percent of all the interviewed households consider a pattern of shopping once or twice per week for major food consumption with some supplementary purchase for fresh vegetables or cooking ingredients more efficient than shopping for food every day. That is to say, the weekly shopping has been widely accepted and practiced as an ideal shopping pattern in Norway. Obviously, shopping less often will lead to shopping more food at any one time and, therefore, a larger food storage place is essential to the household.

[46] Statistics Norway (2011): "Use of time: Around the clock", [online]. –URL: http://www.ssb.no/english/subjects/00/norge_en/tidsbruk_en/13-use%20of%20time.html. (published 2003, retrieved March 16th , 2011)

The importance of cars in saving the shopping trips and time has also been discussed in the open-ended interviews. The use of private cars has increased dramatically since 1960s and right now 54 percent of the population of Norway owns a car[47]. Of all the interviewed households, 6 families didn't drive at the time of being interviewed; including one informant who stopped driving because of old age years ago. Rest of the families own at least one car in the household. People admit that neighbouring food shops might encourage them to do food shopping more often. However, they also make the point that a car is necessary if one wants to buy more but spend less time on the trips. Inger and Tornarne talked about their food shopping habits when they lived in their big house years ago. The food shop was very close, only about five minutes' walk, but they both worked full-time and could only afford to do weekly shopping. Tornarne told me:

> "When we had all our three boys living in the house, we could go out shopping and fill up the car (…) and we didn't have to go shopping every day. We did big shopping once a week or twice a week with some small shopping in between."

Their description of a weekly shopping pattern shows how time pressure has contributed to car-based travels in Norway even if the destination is within a walking distance. Furthermore, it is obvious that a car-dependent shopping pattern inevitably leads to a trend towards less frequent shopping trips. Inger further explained that they could save the shopping trips in this pattern and spend the time saved on other activities.

> "The shop was very close, but we were both working and when we came from work and we didn't want to come back in the house and go out shopping again. We just wanted to go and prepare dinner and then relax."

[47] Statistics Norway (2011): "Transport: Passenger transport." [online]. –URL: http://www.ssb.no/transport_en/main.shtml. (retrieved March 17th, 2011).

Regarding the notion of convenience, cars, together with refrigerators and freezers "are celebrated as offering greater flexibility for the household or for individuals within the household to define their own temporalities" (Silverstone 1993:304). Their role in scheduling time and ordering activities has left Norwegian families more hours for cramming ever more events or leisure activities into a given day or week.

Another change in our shopping patterns is the trend towards shopping for frozen food. The freezer is an instrument useful in the storage of food like frozen meat and fish, pizza, burgers, ice-cream, etc. Of course, households with larger freezer compartments have a tendency to store more frozen food than those having smaller freezers or no freezers installed at home. However, this is not always the case. Ida was married and with no children at the time of being interviewed. Her freezer compartment is "more or less empty", she said. She and her husband both work and they often eat outside, so she never store a lot in her refrigerator or freezer. The rest of the interviewed households keep frozen food of certain kinds and amounts in their freezers. Annette and her boyfriend don't often buy frozen food because their freezer compartment is very small. They only store home-made bread, extra fishes from her boyfriends' fishing activity, some ice-cubes and chopped bananas for fruit shakers in the freezer. Another informant, Ingrid explained that she has some frozen food stored in a separate freezer in her kitchen because

> "when I am busy and I haven't time to cook, I will buy some fast food, just in case and I will put it in the small freezer (…) just for convenience (…) I am allergic to bread, so I buy a special kind of bread (…) I have to buy a lot of them if I go shopping (…) It's convenient for me to take them out from the small freezer and bake them every time."

Inger's freezers are always full. She keeps in there boxes of homemade strawberry and Titibær[48] jam, kinds of meat that she bought when there was a big sale. When she makes *boller* (donuts), she usually keeps them in the freezer. For instance, if she makes 20 donuts and eats 2 of them, she normally puts the rest in the freezer. She told me "when my grandchildren come over, we just heat them [donuts] in the oven, it's convenient". As to frozen fast food like pizza, she usually buys three or four and always have some extra ones kept in the freezer downstairs. She explained that pizzas are for her grandchildren. When they come to their house after school, the children can have pizza and then do their homework.

A social view of energy consumption (Shove et al. 1998, Wilhite et al. 2000) is useful in interpreting the behaviour of these individual freezer users. In Norway, the freezer has become an instrument useful not only for the storage of food but also for the management of people's daily schedule for convenience and in coping with the unexpected. In terms of value of time, scheduling and co-ordination, the freezer has already played an active role in every household, but how it works out is "likely to vary from one household to the next, depending upon their style of 'clocking' and the temporal order of the home" (Shove 2003:117).

One more possible factor relevant to the changing shopping patterns might be a trend towards more refrigeration-dependent cooking practices. Wilhite has argued that refrigerators and freezers have a potential "to save food preparation time by cooking in bulk, storing and reheating" (Wilhite 2008:64). From the interviews, I have noticed that less than half of the interviewed households deliberately arrange their weekly cooking in that way, however, almost all the families have talked about how they keep leftovers in the refrigerators or freezers and reheat them afterwards before eating. Single-

[48] A kind of berry that Norwegians use to make jam and serve with meat.

person households tend to store and reheat food more often. The way that Otto arranges his cooking and eating per week is a typical example. Otto lives alone. He doesn't always have enough time to shop or cook because he works full-time and he thinks it not economically efficient to shop and cook a dinner himself every day. In this sense, how often to go shopping and what to buy is always an issue. He shops for meat products once a week and vegetables more often. During the weekends, he prepares homemade meals from which he keeps leftovers for a day or two in the following week. Of course leftovers go into the refrigerator. He usually takes the leftover out of the refrigerator and warms it in the microwave oven or on the stove before consuming the food. Sometimes, the leftovers of stew or pork are enough for many days' dinner, Otto normally keeps them in the freezer for future consumption. When asked about his diet of half processed frozen food, Otto explained that

> "it would normally be dinner type of food (…) TV dinner or something. So it could be a pasta type of dinner (…) When I don't have time to make my own dinner, I just take it out of the freezer either warm it up on the stove or in the microwave(…) I mainly prefer home-made food."

As described, Otto's weekly cooking routine shows the potential of the refrigeration appliances to save shopping trips and cooking time, which, ultimately, contributes to its decisive role in daily practices. People who live alone are more likely to prepare food in bulk, reheat and eat the food after it has been stored for days in the refrigerators or freezers. Meanwhile, the fact that they tend to consume frozen ready meals more often bears the possibility to "an increasing use of another convenience appliance, the microwave oven, which was designed to quickly heat, re-heat, and defrost and cook frozen foods (Wilhite 2008:65).

In Norway, one-person households continue to increase and have made up to almost 40 percent of the households in 2001[49]. With the growth in single-person living, perhaps a more frozen food shopping and refrigeration dependent cooking culture develops in the future. This will probably result in an increasing energy use for domestic refrigeration.

4.3 Food safety

One issue concerning refrigeration energy intensity that clearly needs addressing is food safety. This section will look at some of the people's perceptions of a safe temperature for fresh food and people's routinized habits of food hygiene, both of which bear implications of an increasing home energy use.

4.3.1 Temperature control

The legislation affecting food safety started to address bacteriological contamination rather than chemical adulteration when the role of bacteria was fully understood in the late 1900s (Garnett 2007:57). Lower temperature has since been considered as one of the most effective ways to control or even kill bacteria. Thus, certain types of foods, according to international health and safety regulations, are required to be held under temperature control. The legal maximum for chilled foods has been raised to 8℃ to avoid or lessen the possible "growth of pathogenic micro-organisms or the formation of toxins" (Health and Safety Executive2011:1) while frozen foods should be stored at -18℃ or lower (Garnett 2007:57). In this way, 8℃ and -18℃ have become a temperature standard for preserving food in the refrigerator and freezer. In my

[49] Statistics Norway (2002): "Population and Housing Census 2001: steady increase of small households." [online]. –URL: http://www.ssb.no/fobhushold_en/main.html. (published September 2nd, 2002)

study, the Norwegian households set their refrigerators at an average temperature of around 5℃, almost 3℃ lower than the standardized temperature maximum. Fifteen households have their freezers set at -18℃ and two households set their separate freezer at a temperature as low as -20℃. Obviously, it is reasonable to believe that more electricity is consumed to keep the refrigeration appliances at a lower temperature, which in turn leads to higher energy intensity in household refrigeration.

In addition, certain types of foods such as potatoes, apples can stay fresh for quite a long time without refrigeration. Most foods can stay fresh in the room temperature if they are to be cooked and eaten within a day of purchase. However, actually, many people in Norway tend to keep everything in the refrigerator or freezer because they trust a lower temperature better than the room temperature in terms of food preservation. Otto put all his daily consumption type of food except canned or dried food in his refrigerator because he thinks “if I keep them in the fridge, it will last a bit longer (…). They stay fresh or at least acceptable”. Helga also indicated the importance of a lower temperature for milk by saying that “if I forget to put it in the fridge, the milk is getting warm and it’s getting bad (…) I can’t drink it any more”.

Actually, all interviewed households consider that dairy products, eggs, meat, fish should be kept in the refrigerator rather than at room temperature although sometimes they are supposed to be consumed within the same day of purchase. Over 50 percent of the interviewed households just put in their refrigerators and freezers everything except canned or bottled foods such as preserved cucumbers or fishes, ketchups and fish oils, etc. However, once the tins or packages of the canned or bottled food are open, they are put in the refrigerator immediately.

All of the above descriptions indicate a widely accepted point of view of temperature control of the food: food can stay longer under refrigerated

conditions than at room temperature. Of course, it is logical to believe in a lower temperature inside the refrigerator or freezer when considering that the average room temperature has been raised to as high as about 23℃. Without refrigeration in such a high temperature, foods are more likely to go bad and cases of food poisoning would be far greater. Therefore, the pursuit of a safer temperature for food preservation at home is likely to have encouraged the people to lower the temperature inside the refrigerator or freezer at which chilled or frozen food is kept, and in turn could have increased the household energy use.

4.3.2 Food hygiene

Improper food handling might cause health problems. Bruhn has indicated that "the most common food handling problems by consumers are obtaining food from unsafe sources, inadequate cooking or heat processing, improper cooling, intervals of 12h or more between preparation and eating, poor hygiene or colonized person handling implicated food" (1998:74). Garnett has also pointed out that our knowledge of food hygiene in the household usually covers hand washing, storing food and cooking food properly (Garnett 2007).

The Western tradition of food preparation has shown that cold dishes are one of the most significant parts of people's everyday diet. Western people pay more attention to a safe temperature control of food than an adequate heat processing. Norwegians tend to eat cold meals more often than warm dishes. All of the interviewed families store their daily consuming type of food such as *pålegg*[50] in the refrigerator. People usually prepare open sandwiches with all kinds of refrigerated *pålegg*. They think it is safe to consume food stored in the refrigerator if it is not overdue the consuming deadline. Sometimes, people

[50] *Pålegg* refers to all kinds of food stuff (meat, fish, vegetables, etc) that can be spread on the bread slice to make open sandwiches.

also heat the dishes stored in the refrigerator before eating. It is not because they think the food needs adequate cooking, but because they like the warm taste of the food. One of my informants, Kim, insisted that dishes like meat or fish should be reheated before eating because both should be eaten warm. Whether there are bacteria in the refrigerated food is only his second thought.

In addition, some of the Norwegians believe eating refrigerated food, which might contain certain bacteria, is actually good for their health. Ivar told me that he feels quite safe to eat the cold food because he has never been sick before. When asked about the bacteriological infection, he told me that "it's good to expose ourselves to some bacteria because it's good to our body's immune system".

Of course, Norwegians pay quite a great deal of attention on the need to cool and thaw food properly. For instance, they always put leftovers in the plastic container and then refrigerate them. Several informants even emphasize the need to cool the leftovers in the room temperature before they are refrigerated because they think the warm temperature might cause a spread of bacteria, even in the refrigerator. However, generally speaking, Norwegians trust the refrigerated food. The cooling of food is, in most cases, their secondary consideration rather than a focus on food poisoning.

Concluding remarks

This chapter has revealed the way that temperature-controlled storage has become the dominant means of preserving food in the household. In an effort to study the energy consumption of domestic food refrigeration, I have paid much attention to the relation between the rising individual refrigeration-dependence and the energy services provided by household refrigerating appliances. Obviously, living in warm spacious houses, eating types of

homemade leftovers or fast food followed by some cold drinks are described by many people as a comfortable life. Meanwhile, the "double burden" (Wilhite 2008:66) on the working women and the accompanying changing shopping patterns have gradually added to the potential of refrigerators and freezers as items of convenience. Thus, people's refrigeration-dependent practices develop hand in hand with their changing perceptions and choices of a comfortable, convenient life. In addition, as a means of food storage, refrigeration has played an invaluable role in ensuring that the food we consume is fresh and safe. Our decision on how to make comfortable houses, how often to shop for food and what sorts of food to buy and cook, as discussed in this chapter, have directly affected people's refrigeration demands and behaviours. Therefore, the household demand for a comfortable convenient life and a safe diet has inevitably contributed to a growing dependence on domestic food refrigeration.

5. A less refrigeration-dependent household

Refrigerators entered almost every household in Norway from the late 1960s to early 1970s and freezers became a household necessity in the early 1980s (Table 1, Chapter 1). The refrigerators and freezers in use at that time were highly inefficient, but, undoubtedly, what we eat, how often we shop for food and how much we buy were far less dependent on refrigeration. Energy efficiency in the cold system is primarily achieved through the appropriate application of more energy-efficient refrigeration technologies since refrigerators and freezers entered the mainstream of the market. However, measures to improve the energy efficiency of our refrigerators and freezers have not fostered a shift towards a less energy intensive household for refrigeration. In this sense, the challenge is not only to "reduce the impacts of those refrigeration systems", but also "to reduce our reliance on refrigeration" (Garnett 2007:72).

Then what might lead to a less refrigeration-dependent household? The aim of this chapter is to suggest some possible ways towards a less refrigeration-dependent household. I will look at some relevant policies or institutional practices that have been implemented or are under consideration and, in addition, raise some questions that may require further investigation.

5.1 Shopping patterns

A shift from weekly shopping to more frequently purchasing food makes it possible for households to have refrigerators of smaller size (Garnette 2007:73). However, it might not be an ideal option for Norwegians. According to the interviews in my study, more than half of the households, either living in

the city or in the outskirts, go shopping by car. Some of them actually live not far from the food shops, but they have a tendency to shop in bulk once or twice a week in order to save shopping time. Eight families live in Oslo and go shopping on foot quite often. This is mainly because their residential places are within a walking distance from the food shops and partly because some of the informants are in an economic situation that makes car-driving impossible at the time of being interviewed. In addition, half of these eight families have talked about the time pressure and expressed their strong preference to weekly shopping in the interview. In this sense, for the sake of convenience, a practice of car-dependent weekly shopping might be more favorable and acceptable to most of the Norwegian households who rely heavily on time-scheduling and car-driving.

The Norwegian planning policies certainly have an effect on the people's choices of food shopping styles. The policies of Norwegian planning authorities, for example, the 1999 national policy guidelines of shopping centres outside central business districts[51], obviously have encouraged "the development of out-and edge-of-town shopping centres, spurring the trend to the large weekly shop" (Garnett 2007:73). Statistics have shown a sharp reduction of grocery shops within 4 kilometers to people's residential areas from 2004 to 2007 in the sampling area[52], which implies shopping on foot daily is usually not an option for people living there. Recent government policies on planning and building have shown some signs of the growth of

[51] Statistics Norway (2010): "Land Use in Central Business Districts." [online]. –URL: http://www.ssb.no/english/subjects/01/01/20/arealsentrum_en/about.html. (retrieved April 1st, 2011).

[52] Statistics Norway (2011): "Personer som bor innen 4 km fra ulike tilbud i nærmiljøet, etter kjønn og alder (prosent)." [online]. –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=0&tilside=selectvarval/define.asp&Tabellid=05787. (retrieved April 4th, 2011).
Statistics Norway (2011): "Personer som bor innen 4 km fra ulike tilbud i nærmiljøet, etter landsdel (prosent)" [online]. –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=0&tilside=selectvarval/define.asp&Tabellid=05789. (retrieved April 4th, 2011).

smaller, more central stores in the local community[53]. This trend of expansion of more local stores might provide an increased incentive to encourage consumers to move away from shopping weekly.

The Norwegian tax policies of imported private cars and gasoline have turned car-driving into one of the highest daily expenditure for households. The high cost of car trips might have discouraged some potential users of private cars, and thus move certain potential customers away from a car dependent shopping pattern. However, the private car population has kept on expanding during the past 30 years. In 2008, the total stock of private cars and vans in Norway has increased over 50 percent of the total amount in 1985[54]. Up to 2008, an average of two persons, or almost every household, has the ownership of a private car or van in Norway[55]. In the real use context, the growing stock of domestic vehicles provides a very strong incentive for consumers' weekly car-dependent shopping practices.

Therefore, in order to promote a more frequent, less car-dependent local shopping habit, it is important to make policies that will promote a network of more local food shops. At the same time, consumers should also be provided with more transportation alternatives. This can be achieved by setting up more comprehensive local transportation systems. These well-intentioned initiatives certainly require further investigation before being put into practice; however, they could become big steps towards moving into a less refrigeration-dependent household once being implemented.

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[53] Lov om planlegging og beggesaksbehandling (plan- og bygingsloven) (2011):"Kapittel 11. Kommuneplan." [online]. –URL: http://www.lovdata.no/all/tl-20080627-071-017.html#11-7. (last updated May 18th, 2011).

[54] Statistics Norway (2010): "Registered Passenger Cars and Motor Vehicles" in *Statistics Year Book 2010*. [online] –URL: http://www.ssb.no/english/yearbook/fig/fig-420.html. (retrieved May 19th, 2011).

[55] Statistics Norway (2011): "Stock of Vehicles and Population." [online] –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selectvarval/define.asp&Tabellid=04759 . (retrieved May 19th, 2011).

5.2 Size and amount

A shift towards a less-refrigeration dependent household could benefit from a rethink of the required size and amount of domestic refrigerating appliances. The trend towards larger refrigerators and freezers in the kitchen and an afterlife use of disposed refrigerators and freezers in the basement or garage, as described in chapter 4, have definitely contributed to the growth of domestic energy use for cold appliances (Strandbakken 2009:149). Thus "it would be environmentally desirable for us to shift towards purchasing smaller fridges" (Garnett 2007:74) or taking old refrigeration products out of services.

However, up to now, according to Wilhite & Norgard (2004), the energy saving policies and programs of cold appliances have been focused on "developing better technologies and on using minimum efficiency standards and labels to convince consumers to buy the most efficient technology". Fewer or even no emphasis has been laid on "the technological development of more efficient versions of small refrigerators" (996). Normally, larger refrigerators and freezers are labeled as more energy efficient than smaller ones because they consume less energy per cubic foot. Therefore, we can't deny the fact that such policies as the energy-labeling scheme have actually accelerated the trend towards large cold appliances and, in turn, the market for smaller-sized fridges and freezers is shrinking.

Also, it is important to stress that it is the consumers' choice that will be decisive in how many and what kind of refrigerators to use in the household. In the study, more than 80 per cent of the households admitted that they could not live without refrigeration appliances while very few families said that they could survive with no refrigerators at home. Thus, in reality, it is hard for Norwegian people to imagine a life without refrigerators or freezers although they admit that they could survive with fewer ones or refrigerators of smaller size.

The change towards a smaller refrigerator or freezer at home might lead to a substantial change in life styles for Norwegians. Helga, a girl of 25 years old, worries that she has to spend more time shopping every day and she must have a good selection of food when shopping and then decide more carefully what should go into the refrigerator. Kim, a 30-year-old IT engineer, lives with his wife and they have a standard 300-liter fridge-freezer in their apartment. Kim told me it might cause great inconvenience to them if they change their current fridge-freezer into a smaller one because there would not be enough refrigerating space to keep the food when they shop quite a lot. Inger and Tormarne, a couple in their sixties, described the life with less refrigerating units would be "really difficult" and the wife said "that's not for us now." It is obvious that the change to smaller and fewer refrigerators and freezers, according to most of the Norwegians, implies a less comfortable, inconvenient and unsecure life, which means that they have to go shopping more often, re-schedule their time for social and leisure activities and even change their daily diet. So far in Norway, to my knowledge, very few or even no energy saving policy efforts have been devoted to the promotion of people's willingness to accept refrigerators and freezers of smaller size or reduce the amount of the refrigerators and freezers in the household.

A shift towards a smaller domestic food refrigeration capacity doesn't necessarily mean that we have to return to natural refrigeration to ensure much lower energy consumption. The point I am trying to make here is that it is important to develop energy saving policies by taking into consideration not only technological efficiency but the human factors and the energy services provided by the technologies. It is of vital importance to give consumers a possible birds' view of indoor energy consumption and to grant people extensive flexibility to make decisions on their energy choices.

5.3 Food types

Over the last 30 years, Norwegian food behaviour has experienced a considerable change. Statistics listed in Table 2 (Chapter 4) have shown a growing trend in use of more refrigeration dependent food such as meat, fresh vegetables and fruit. Thus, a shift away from a more refrigeration-dependent diet may help to reduce the energy intensity of the household refrigeration.

Food containing fat, especially saturated fat tend to be more refrigeration reliant than any other food stuff (Garnett 2007). Thus, a decreasing consumption of food containing saturated fat could lead to a less demand for food refrigeration. Norwegian nutrition policy has long laid much emphasis on a healthier diet with less consumption of fat[56].The proportion of fat in the Norwegian diet has decreased from 40 percent in the late 1970s to 34 percent in the early years of this century[57]. However, the proportion of saturated fat has remained constant, still at a level around 1/3 higher than the recommended level specified by diet specialists[58]. This is mainly because the decline in consumption of full-fat milk, margarine, butter and other fats has been compensated by an increased consumption of meat and cheese, especially during the past decade (Kjærnes 2003:251). In this sense, policies that seek to influence people's consumption of food containing saturated fat should be further discussed and implemented. The most recent Norwegian Action Plan on Nutrition (2007-2011), Recipe for a Healthier Diet, "(…) developed through the collaboration of 12 Ministries", "(…) contains specific measures

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[56] Northern Ireland Assembly (2009): "Norwegian Nutrition Policy and Nutrition Campaigns." [online]. –URL: http://www.niassembly.gov.uk/researchandlibrary/2009/9509.pdf. (retrieved April 13th, 2011).

[57] Northern Ireland Assembly (2009): "Norwegian Nutrition Policy and Nutrition Campaigns." [online]. –URL: http://www.niassembly.gov.uk/researchandlibrary/2009/9509.pdf. (retrieved April 13th, 2011).

[58] Norwegian Ministries (2007): "Recipe for a Healthier Diet – Norwegian Action Plan on Nutrition (2007-2011)." [online]. –URL: http://www.regjeringen.no/en/dep/hod/Subjects/the-department-of-public-health/norwegian-action-plan-on-nutrition-2007-.html?id=534268. (retrieved April 13th, 2011).

to promote health and prevent illness by changing eating habits in line with nutrition recommendations"[59]. It has suggested "a switch in the consumption of meat and dairy products to low fat products" in order to lower the total fat intake, especially the percentage of saturated fat[60]. In my study, Annette, a girl of 26, told me that she and her boyfriend stopped eating meat and meat products in 2004 because they think that the resource of the meat is not good and people eat too much meat. Kristinge talked about a considerable energy intensity of meat production and that's why her family has turned to eat more fish than meat. Ingrid considered a diet of a large portion of unsaturated fat to be had for her health. All the above discussion and evidence have suggested a shift towards people's daily intake of less saturated fat, which bears the potential to move the Norwegian food habit towards a pattern of less refrigeration-dependent consumption.

A shift away from refrigeration-dependent vegetables and fruit to seasonal and "more robust" ones could also reduce reliance on household food refrigeration. Garnett's study on the relationship between greenhouse gas emissions and fruit and vegetables has shown that unseasonal food, half-processed produce, fragile and perishable vegetables and fruit are highly GHG (Greenhouse Gas Emission) intensive in their production, transport and storage while seasonal field grown foods and overseas grown "robust" produce are fairly low in their GHG intensity (2006:7-8). In Norway, the consumption of fresh vegetables has increased by about 12 percent from 1975 to 2008, while fresh fruit has increased up to around 3/5 of the total fruit consumption (See Table 1, Chapter 4). The growing consumption of fresh vegetables and fruit definitely requires more energy use in transport refrigeration or cold storage in retailers and

[59] Northern Ireland Assembly (2009): "Norwegian Nutrition Policy and Nutrition Campaigns." [online]. –URL: http://www.niassembly.gov.uk/researchandlibrary/2009/9509.pdf. (retrieved April 13th, 2011).

[60] Norwegian Ministries (2007): "Recipe for a Healthier Diet – Norwegian Action Plan on Nutrition (2007-2011)." [online]. –URL: http://www.regjeringen.no/en/dep/hod/Subjects/the-department-of-public-health/norwegian-action-plan-on-nutrition-2007-.html?id=534268. (retrieved April 13th, 2011).

supermarkets. There could be trade-offs between, on the one hand, the energy used to transport and commercially store fresh vegetables and fruit, and on the other hand, the energy used for long-term refrigerated vegetables and fruit in the household. However, we have to admit that it is less demanding in the household use of refrigerators and freezers since many of the fresh vegetables and most of the fresh fruit are not prepared for long-term consumption and do not necessarily require refrigerating at home. Some of the informants have told me in the interviews that their purchased vegetables and fruit will most likely stay at room temperature for consumption during the day or in the refrigerator for a day or two before being consumed. Almost all the informants like to eat fresh vegetables and fruit every day because fresh ones are always available in the food shops. No interviewed households store frozen vegetables (except some frozen potatoes for fried potato chips), and very few of the interviewed families store frozen fruit in their freezer. Hildur, an 82-year-old lady living alone, always keeps some apples or berries in her freezer because, as she told me, it is her habit to have some frozen fruit as backups for baking cakes or pies.

All the above information from the interviews has shown that it would be possible for policies on refrigerating energy reduction to highlight the benefits from a diet of less saturated fat and more vegetables or fruit, a diet of less frozen food but more fresh ones. Meanwhile, policy-makers could call on consumers to follow a less refrigeration-reliant food storage pattern, for instance, to keep the food for short-term consumption, such as meat, dairy products, vegetables and fruit, outside the refrigerators or freezers.

5.4 Safety and quality

Norwegians' trust in food refrigeration might have caused them to overuse refrigerators and freezers. Thus, a move away from the notion of keeping food

at a safe temperature to the notion of cooking food adequately makes it possible to reduce our dependence on food refrigeration. It doesn't necessarily mean that temperature control of food should be secondary messages to consumers. My point here is that traditional food safety messages have laid too much emphasis on the need to cool and thaw foods properly. Actually, according to Medeiros et al., inadequate cooking of the refrigerated or frozen food, especially eggs and meat products might cause more serious illness than inadequate control of refrigeration (2001:111).

Of all my informants, nobody considers that refrigerated or frozen meat, eggs, fish or dairy products need adequate cooking which suggests a time and temperature combination in order to produce food of acceptable quality. Households in a habit of cooking in bulk, store the cooked food in the fridge or freezer usually reheat the leftovers before eating just for a warm taste. No informants warm the leftovers to avoid pathogens existing in foods. Surprisingly, all the interviewed families have mentioned in a unanimous way that the temperature control of a household refrigerator or a freezer is safe enough to keep food in good or, at least, acceptable quality although they agree that different food requires different cooling conditions and measurements. Almost all the informants use visual cues to judge whether refrigerated or frozen meat, eggs and fish leftovers are safe to eat and no one deliberately evaluate whether the refrigerated food is adequately cooked before being consumed.

Recently, food safety programs have started to emphasize the importance of adequate cooking. "The Fight BAC! Pamphlet gives endpoint cooking temperatures for meats, and the U.S. Department of Agriculture has launched a campaign to encourage consumers to cook food at a safe internal temperature

(Medeiros et al 2001:111). The Norwegian food hygiene policies[61] have already emphasized measures both for food chains and households to control hazards and, meanwhile, to ensure that food is fit for human consumption. It has suggested some relevant household food hygienic principles although some domestic hygiene conditions are not regulated. However, very limited attention has been paid to adequate cooking messages on meat, eggs and dairy products. Of course, there might be trade-offs between, the energy used to achieve a lower refrigeration temperature and the energy used to ensure safe and adequately cooked food. Therefore, further research is needed to determine effective hygiene principles for adequate heating for food.

Regarding the quality of food, there is no sharp distinction between food safety regulations and nutrition policies (Kjærnes 2003:255). Obviously, fresh food is of better quality than refrigerated or frozen food and it may contain more nutrition. It is true that the development of refrigeration technology has made it possible to store food for a longer period of time, however, we have to admit that, in some circumstance, the technology "has been utilized to make old food eatable rather than to make fresh food available" (Wilhite & Norgard 2004:996). Therefore, keeping consumers away from the notion of eating food of acceptable quality, to some extent, might also reduce their reliance on refrigeration.

5.5 Indoor temperature control

It is possible to reduce reliance on food refrigeration by keeping houses cooler. Obviously, keeping houses cooler could improve the storage life of food, especially those such as perishable vegetables, fruits, dairy products and fish or meat, if they are not refrigerated. In my study, some of the interviewed

[61] The Ministry of Health and Care Services (2011): "Næringsmiddelhygiene." [online]. –URL: http://www.regjeringen.no/en/dep/hod/tema/ernaring-og-mattrygghet/naringsmiddelhygiene.html?id=570213. (retrieved May 19th, 2011).

families are accustomed to leave their purchased food at room temperature if they are going to eat it the same day. In this sense, kitchen temperature could be considered as one of the decisive factors to the storage life of food. One of the interviewed families deliberately tried to keep their kitchen temperature down at 18℃, about 4℃ lower than their living room temperature. They explained to me that's because they like to store quite a lot of vegetables and fruit, especially those for one or two days' consumption, on the kitchen table. However, they have found that sometimes it's hard to keep the kitchen temperature down because all the rooms in their residential place are heated except the basement, and their small kitchen easily gets much warmer when they are cooking. Therefore, the usual temperature of their kitchen is somewhere between 18℃ to 20℃.

Garnett has recorded the energy-reduction recommendation of some environmental organizations: "turning the thermostat down just one degree can save ×××% off your energy bills" (2007:74). It might be one of the effective suggestions to Norwegian households because the average electricity price in Norway has gone up to about 39 øre per kWh at the end of 2008, more than double the price of ten years ago[62]. The interviewed households in my study, more or less, are concerned seriously about their electricity bills when they budget their indoor energy use. However, we can't deny the fact that a well-accepted comfortable winter living room temperature in Norway has been stabilized around 22-23℃ for almost 20 years (see chapter 4) and Norwegians are in a habit to heat all the rooms in the house except the basement. As a living standard, a lower room temperature might be considered as uncomfortable or even culturally unacceptable in Norway. Therefore, it would be more realistic to recommend a lower kitchen temperature rather than to cool

[62] Statistics Norway (2011): Table: Electricity Prices in the Wholesale Market (øre/kWh)." [online]. –URL: http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selectvarval/define.asp&Tabellid=04725. (retrieved May 16th, 2011).

down Norwegians' whole indoor living space for the sake of their culturally-embedded demand for domestic ambient heating.

5.6 Sustainable community development

The change of households' dependence on domestic food refrigeration is closely related to almost all important factors in our daily life such as our residential space, family size, all human events in the life cycle, routinized shopping patterns and food habits, etc. In the open-ended interview, most of the informants expressed their concern about the size of their residential places, their annual expenditure of electricity, the location of the local grocery stores, and the public transportation in the community. For instance, all informants over 60 years old talked about price of house and electricity. Inger and Tormarne are now worrying very much about their grandchildren's economic status to afford a house and daily electricity consumption because they think that houses and electricity are turning to be exceptionally expensive compared to what they were fifteen years ago. Almost all households have talked about the distance from their place of living to the food shops nearby and considered shopping by car is, to some extent, a daily necessity because they like to buy in bulk, which is not possible if they take the public transportation. Thus, a shift towards a less refrigeration dependent household is more than just a self-reliance to reduce energy consumption, but a complicated social-economic issue which implies a sustainable development of all factors relevant to human settlements.

The development of sustainable communities might be a possible solution to the ever-growing households' energy demand, but it is not an easy task to accomplish. According to Mark Roseland, the global environmental degradation results largely from the postwar pattern of wealthy developed communities. In his point of view, these communities are not only ecologically

but economically and socially unsustainable because "it is these unsustainably 'developed' (original) cities of the world that produce most of the world's solid and liquid wastes, consume most of the world's fossil fuels, emit the majority of ozone depleting compounds and toxic gases, and give economic incentive to the clearing of the worlds' forests and agricultural lands" (2000:74). Communities of this kind have been planned, developed and existed for more than half a century and people have been accustomed to the life in these communities. Therefore, a move towards sustainable community development requires a significant change in our structures, attitudes and values to existing social and material practices.

The new kind of *ecosystem* thinking about community, as described by Brugmann and Hersh, "provides a tool to understand the complex relations between human activities and the environment, and how communities can organize their activities to both meet human needs and benefit the environment (…)" (Roseland 2000:102). Based on this recent concept, examples of sustainable community development worldwide has, in various aspects and degrees, accelerated a trend towards a less refrigeration dependent life style. For instance, a less car-reliant shopping pattern can be expected with *car co-operative*, a scheme planned and implemented in Vancouver, to reduce the cost and necessity of car ownership in Vancouver. So are the *non-automobile transportation* policies that encourage increased use of public transportation, cycling and walking (Roseland 2000:97-113). The example of Portland's (Oregon) "i*ncreasing affordable housing supply* through zoning codes that promote a variety of housing types, including smaller and multi-family homes" (Roseland 2000:97) might have reflected the guiding principles of adequate shelter and have encouraged multi-family households. The suggested alternative choice towards affordable but smaller place of living or a co-habitant pattern of extended families could bear the implication of a less demand for energy-intensive appliances in the household. Also, the c*ommunity supported agriculture* program run in Vancouver, London, Ontario and New

York City, make fresh vegetables and fruit available in the city neighborhood (Roseland 2000:97-98). In this case, the local consumption of more seasonal and "more robust" produce could reduce the households' dependence on food refrigeration.

All the above examples suggest that the development of sustainable communities is now happening globally. Sustainable communities have been increasingly accepted as not just a bitter necessity to reduce material and energy consumption, but a new opportunity to provide an alternative vision of a genuinely better life (Roseland 2000:126). However, not all examples of sustainable community development can be patterned as solutions towards a less refrigeration-dependent household in Norway. It is always challenging to figure out specific conventions of the local community and adjust residents' unsustainable perceptions and routines towards sustainable practices. Therefore, it is essential to take a serious consideration of the feasibility of sustainable community programs in a local social-material context before they are put into practice.

5.7 White certificate

The implementation of the so-called "Tradable White Certificate" (TWC) scheme could also influence the household energy intensity of refrigeration.

TWC schemes try to impose obligations on energy suppliers or retailers to achieve energy savings through the improvements in the efficiency of energy use by consumers. Bertoldi and Rezessy defined a TWC as:

> A white certificate is an instrument issued by an authority or an authorized body providing a guarantee that a certain amount of energy savings has been achieved. Each certificate is a unique and traceable commodity that carries a property right over a certain amount of additional savings and guarantees that the benefit of these savings has not been accounted for elsewhere. (2006:35)

In recent years, TWC schemes of different design have been studied and/or implemented in some European countries such as Great Britain, Italy, France, Netherland, Demark and Poland (Mundaca & Neij 2009:4557). According to Philippe Quirion and Louis-Gaëtan Giraudet (2009), various TWC schemes may be schematically described in the energy saving practices as follows:

> Energy suppliers have to generate a given quantity of energy savings, or, if they are short of their target, to buy certificates from other suppliers. Vice versa, suppliers who have funded more measures than their target are allowed to sell such white certificates to those who are short of their target. In general, in order to be taken into account, energy savings have to take place in energy consumers' dwellings or plants, not in energy suppliers' facilities. In practice, suppliers typically fund energy savings in their own customers' dwellings, or contract with retailers who increase their sales of energy efficient goods in exchange for a funding from the energy supplier. (2)

The above description has shown that energy savings in residential buildings are one of the major targets of a European-wide TWC scheme (Mundaca 2008). The TWC scheme in the UK well supports this point of view. Great Britain run the first TWC scheme, labeled as "Energy Efficiency Commitment" (EEC1) from April 1st, 2002 to March 31st, 2005. The scheme set for the energy supplier a saving target of 62 TWh of energy. "This target refers to savings cumulated and discounted over the lifetime of the equipments funded, not only over the 3-year commitment period." (Quirion & Giraudet 2009:3). It is worth mentioning that this aggregate goal was exceeded by 40 percent during EEC1 and at least half of the target was achieved in the households that received certain-income related benefits and tax credits (Quirion & Giraudet 2009:3-4).

Within the household sectors, electricity consumption represents most of the TWC supply in terms of demand for energy services such as lighting, heating and cooling. Thus, TWC schemes designed to cut down the household electricity demand could be of vital importance to reduce our indoor energy consumption. An idealized national TWC scheme developed by Sorrell et al.

(2009) aims at improving the efficiency of electricity use. He argues that the energy efficiency of services is not determined solely by the electricity conversion equipment, but also by "the attributes of the whole energy system". For instance, the energy efficiency of services of the heating system is relevant to many other factors, such as the thermal insulation in a building. Thus, the scheme described by him allows households "to purchase the combination of electricity and energy efficiency measures (EEM) that maximize their welfare" (29-30).

Up to now, there are very few or even no such TWC schemes specifically designed for domestic refrigeration system. However, the concept of TWC schemes to improve electricity efficiency could be applied to the reduction of the household energy intensity of food refrigeration. When designing a TWC scheme of this kind, the authority can set certain mandatory targets that electricity suppliers are required to meet. The EEM could be related to any refrigeration-relevant energy efficiency services in the supplier-funded households, for example, the heating system in a building, the design of the kitchen, the type of refrigerators and freezers people have at home as well as the way people use refrigerators and freezers in their everyday practices. Any energy savings achieved within the pre-defined criteria of the household refrigeration are to be measured and verified by official regulators as EEM in the form of certificates. Then the credited certificates can be used by the electricity suppliers to meet their energy saving targets or to trade on the EEM market.

Of course, it is worth highlighting that the TWC scheme's energy-saving effectiveness, its economic efficiency and political feasibility are still under discussion (Mundaca & Neij 2009:4569). There might always be trade-offs between the energy saving efforts and the existing demand-side consumption. In addition, TWC schemes are highly country-specific schemes and the actual EEM of those refrigeration-related energy services is a complicated issue

which requires a standard measuring mechanism involving almost all aspects of households' energy practices. Thus, factors of all aspects of life should be taken into consideration when a TWC scheme is to be planned and implemented. By now, of all Scandinavian countries, it seems only Demark has embarked certain ex-ante TWC studies. Therefore, more comprehensive institutional studies and governmental investigations are required before the actual planning, development and implementation of TWC schemes in Norway.

Concluding remarks

A less refrigeration-dependent household will not come easily without a thorough knowledge of what refrigeration dependence is and how we should deal with it. Based on my study, there is no doubt that households' refrigeration is moving towards an increase of number and size of cold storage units. People's growing dependence on refrigerators and freezers is closely relevant to households' decisions on where to live, who to live with, how to shop for food and what to buy and cook. In addition, institutional practices and government policies certainly have potential influences on consumer's expectations of comfort, convenience and food safety, but only subtly and gradually. There are always trade-offs between the targeted reductions in energy use and the continued reliance on energy services. Therefore, refrigeration dependence is a complicated issue to tackle and it requires efforts from government policies, institutional studies and all aspects of energy-consuming practices in our everyday life.

6. Conclusion

Refrigerators and freezers have a potential to be substantial greenhouse gas emitters not only because the refrigerant currently stored in the equipment has a high global warming potential, but because refrigerators and freezers are highly energy-intensive appliances. It is roughly estimated that the minimal annual electricity consumption for refrigeration in the household accounts for at least 3.8 per cent of the total household CO_2 emissions in Norway (chapter 1). The percentage of the greenhouse gas emissions from domestic food refrigeration might be a trivial contribution to the total emissions in Norway. However, according to Garnett, "refrigeration is (…) intrinsically linked to other technological and cultural practices that are (…), in themselves, energy intensive" (2007:76).

Recent development of refrigerating technologies, especially during the last half century, has led to an enormous reduction in refrigeration energy consumption. I have argued that the technical-economic development of cold appliances is important to energy savings in domestic food refrigeration; however, technology alone is not sufficient to a deep reduction of the energy intensity in the household food refrigeration. Obviously, under the general heading of *Ecological Modernization*, the improvements in energy efficiency of electrical cold storage devices are vital contributions to "greening modern lifestyles" (Strandbakken 2009:146-147). However, we have to admit the fact that refrigerating technologies are approaching some practical limits. In addition, the energy savings from the technological improvement of efficient cold appliances, to a large extent, has been eaten up by the "rebound effect" phenomenon. The development of energy-efficient refrigerators and freezers actually lead to a growth, rather than to a reduction of the demand for refrigerating capacity at home. Thus, the actual energy savings from the

technological efficiency gains are always somewhat lower than the ever-expanding households' demand for refrigeration energy services.

This paper has explored the energy consumption of household refrigeration from a social-material perspective where energy intensity is intrinsically linked to not only technological improvements, but social routines and cultural practices. Based on a social-material understanding of human-technology relations, people's food refrigeration choices in the household has been directly influenced by the pre-determined *script* in refrigerating appliances. Meanwhile, people's tacit knowledge and routinized social practices are crucial to develop the function of refrigerators and freezers in the real use context. The data from the open-ended interviews have shown that Norwegians' growing energy demand for food refrigeration in their homes is deeply rooted in their traditional cultural awareness and routinized everyday practices. Most likely, their refrigerating energy demand changes when these culture-based routines or socially embedded practices get disrupted. This changing demand for refrigerating energy intensity in accompany with the adjustment of people's routinized practices opens the possibility for a reduction of energy consumption in the indoor cold system.

When applying the three middle-ranged concepts – comfort, convenience and food safety – to the indoor energy use of food refrigeration, I have found that it is those household demands for energy services, including comfortable homes, convenient lives as well as safe and healthy diets, rather than the refrigerating technology itself that have contributed to people's growing dependence on food refrigeration. My studies have shown that the interactions between people's demand for food refrigeration and their routinized practices of residential space, domestic ambient heating, diet preferences and shopping patterns all have considerable contributions to high household refrigeration dependence. In Norway, it is the size of a house rather than the size of a household that is decisive to the amount and size of refrigerators and freezers

in the household. Larger and warmer homes are generally standardized as comfortable living space and, at the same time, occupy more food refrigerating capacity. In addition, a developing trend towards more refrigeration-dependent food and more preference of cold drinks in Norway have inevitably encouraged people to arrange more refrigerating equipment at home. Apart from that, I have also argued that the time pressure associated with both income-producing work and housework in Norwegian households has turned refrigeration appliances a 'must' for a modern and convenient life. The informants in my study characterized daily food shopping as a weekly, car-dependent practice in order to save shopping trips and time. It is no surprising in a car dominant society that people are accustomed to shop food in bulk and store them in the refrigerator or freezer for future consumption. As to food safety, I have argued that an overstatement of the importance of a low temperature for food preservation in Norway has made invisible some other food safety factors such as personal hygiene or adequate cooking. In this sense, people's trust in cold storage has, to some extent, accelerated their dependence on food refrigeration.

Considering the growing households' refrigeration dependence in Norway, I have come to the conclusion that the energy saving policies and programs need to be targeted at not just technological efficiency of refrigeration appliances, but also people's routinized energy habits and practices. A less refrigeration-dependent household requires substantial changes in what and how much we shop for food, in where and how we buy it, and in how and when we cook it in our daily practices. Further institutional studies and government policies in refrigeration system could also shift their focus towards a much broader development of sustainable lifestyles and communities in which the reduction of the energy intensity of household refrigeration is discussed in association with technologies, routines and human practices in a social-material context. Of course, an extensive flexibility that allows individual refrigeration preferences and choices is crucial in developing energy policies because it

makes possible for people to decide how to meet their personal energy-saving targets effectively.

The following are some initial suggestions to help households save refrigeration energy more efficiently:

- Studies and policy-making efforts could try to focus on the development and manufacture of refrigerators and freezers of smaller size. Of course manufacturers could be allowed for some time to adjust their products towards smaller refrigeration appliances. In this way, households will have a wide enough selection of refrigerators and freezers to meet their own needs and habits.
- More research is needed to examine the ways how consumers use their refrigerating appliances and how such ways affect energy consumption in the household practices. This research opens the discussion on the interaction between technological developments and changing refrigeration-related routines and habits in the household. So far, policy attentions have been heavily focused on encouraging consumers to purchase new energy-efficient appliances while very few or even no polices have been put forward to define a sustainable consumption agenda. Therefore, more studies and research work are essential to the establishment and development of a sustainable techno-behavioral relationship in the refrigerating energy consumption.
- Consumers should have access to more information on energy saving practices of refrigerators and freezers. On one hand, policies could be made to encourage manufactures and retailers to provide consumers with more information on the energy consumption of their refrigerating products. On the other hand, policies could give more emphasis to a less refrigeration-dependent lifestyle in order to achieve a deep energy reduction in the household refrigeration.

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